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# JOURNAL AND PROCEEDINGS

OF THE

# ROYAL SOCIETY

OF

# NEW SOUTH WALES,

EDITED BY

*THE HONORARY SECRETARIES.*

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE OPINIONS EXPRESSED THEREIN.

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1905.

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1905.

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The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

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| ,, | X. | Journal and Proceedings | | | ,, | ,, 1876, | ,, 333, | | ,, |
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| ,, | XXXI. | ,, | ,, | ,, | ,, | ,, 1897, | ,, 626, | | ,, |
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| ,, | XXXVII. | ,, | ,, | ,, | ,, | ,, 1903, | ,, 663, | | ,, |
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| 1905 | | Anderson, Charles, M.A., B.Sc., *Edin.*, 'Moa,' Roslyn Gardens, Darlinghurst. |
| 1903 | | Arnot, Arthur James, A.M.I.C.E., M.I.M.E., M.I.E.E., Electrical Engineer, 83 Pitt-street. |
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| 1878 | | Backhouse, Alfred P., M.A., District Court Judge, 'Melita,' Elizabeth Bay. |
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| 1900 | | Bale, Ernest, C.E., Public Works Department. |
| 1894 | | ‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z. |
| 1896 | | Barff, H. E., M.A., Registrar, Sydney University. |
| 1895 | P 10 | Barraclough, S. Henry, B.E., M.M.E., Assoc. M. Inst. C.E. Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Lecturer in Mechanism and Applied Thermodynamics, Sydney University; pr. 'Marmion,' Victoria-street, Lewisham. |
| 1903 | | Bayly, Francis William, Assayer, Royal Mint, Sydney. |
| 1894 | | Baxter, William Howe, Chief Surveyor Existing Lines Office, Railway Department, Bridge-street. |
| 1877 | | Belfield, Algernon H., 'Eversleigh,' Dumaresq. |
| 1876 | | Benbow, Clement A., 48 College-street. |
| 1900 | | Bender, Ferdinand, Accountant and Auditor, 21 Elizabeth-street, North. |
| 1869 | P 2 | Bensusan, S. L., Equitable Building, George-st., Box 411, G.P.O. |
| 1905 | | Bignold, Hugh Baron, Barrister-at-Law, Chambers, Wentworth Court, 64 Elizabeth-street. |
| 1901 | | Birks, Lawrence, B. Sc., Assoc. M. Inst. C.E., A.M.I.E.E., F.G.S., City Electrical Engineer, Christchurch, New Zealand. |
| 1905 | | Blakemore, George Henry, General Manager for the Great Cobar Mining Syndicate, Lithgow. |

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| 1888 | | ‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Fremantle, West Australia. |
| 1893 | | Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra. |
| 1898 | | Blunno, Michele, Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture, Sydney. |
| 1905 | | Board, Peter, M.A. *Syd.*, Under Secretary and Director of Education, Department of Public Instruction, Sydney. |
| 1879 | | ‡Bond, Albert, 131 Bell's Chambers, Pitt-street. |
| 1904 | | Bosch, Ernest, Consulting Optician, Mutual Life Building, Martin Place. |
| 1891 | | Bowman, Archer S., B.E., 'Keadue,' Elizabeth Bay Road. |
| 1893 | | Bowman, John, Assoc. M. Inst. C.E., c/o T. A. Kemmis, Esq., 163 Phillip-street. |
| 1876 | | Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 3 Lyons Terrace, Hyde Park. |
| 1891 | | Brennand, Henry J. W., B.A., M.B., Ch. M. *Syd.*, F.R.A.S., F.C.S., 231 Macquarie-street. |
| 1902 | | Brereton, Victor Le Gay, Solicitor, Tattersall's Chambers, Hunter-st.; p.r. 'Osgathorpe,' Gladesville. |
| 1878 | | ‡Brooks, Joseph, F.R.A.S., F.R.G.S., 'Hope Bank,' Nelson-street, Woollahra. |
| 1876 | | Brown, Henry Joseph, Solicitor, Newcastle. |
| 1903 | | Bruck, Ludwig, Medical Publisher, 15 Castlereagh-street. |
| 1898 | | ‡Burfitt, W. Fitzmaurice, B.A., B. Sc., M.B., Ch. M. *Syd.*, 311 Glebe Road, Glebe Point. |
| 1890 | | Burne, Dr. Alfred, Dentist, 1 Lyons Terrace, Liverpool-street. |
| 1880 | | Bush, Thomas James, M. Inst. C.E., Engineer's Office, Australian Gas-Light Company, 153 Kent-street. |
| | | |
| 1904 | | Cambage, Richard Hind, F.L.S., Chief Mining Surveyor, Park Road, Burwood. |
| 1904 | | Cameron, John Mindoro, Assoc. M. Inst. C.E., Engineer, Public Works Department; p.r. Hotel Metropôle, Sydney. |
| 1900 | | Canty, M., 'Rosemont,' 13 York-street, Wynyard Square. |
| 1876 | | Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd., Edgecliffe. |
| 1897 | P 3 | Cardew, John Haydon, Assoc. M. Inst. C.E., L.S., 75 Pitt-street. |
| 1901 | | Card, George William, A.R.S.M., F.G.S., Curator and Mineralogist to the Geological Survey, N.S.W., Department of Mines. |
| 1891 | | Carment, David, F.I.A. *Grt. Brit. & Irel.*, F.F.A. *Scot.*, Australian Mutual Provident Society, 87 Pitt-st. *Hon. Treasurer.* |
| 1903 | | Carslaw, H. S., M.A., D. Sc., Professor of Mathematics, Sydney University, Glebe. |
| 1879 | P 1 | ‡Chard, J. S., Licensed Surveyor, Armidale. |
| 1878 | | Chisholm, Edwin, M.R.C.S. *Eng.*, L.S.A. *Lond.*, Victoria-street, Ashfield. |
| 1885 | | Chisholm, William, M.D. *Lond.*, 139 Macquarie-street, North. |
| 1896 | P 1 | Cook, W. E., M.C.E. *Melb.*, M. Inst. C.E., District Engineer, Water and Sewerage Department, North Sydney. |
| 1904 | | Cooksey, Thomas, Ph. D., B.Sc. *Lond.*, F.I.C., Second Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman. |
| 1903 | | Cooper, David John, M.A., 'Grasmere,' 151 Stanmore Road, Stanmore. |

| Elected | | |
|---|---|---|
| 1876 | | Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.R.C.P. *Edin.*, 'Wynwood,' Wahroonga. |
| 1876 | | Colyer, J. U. C., 'Malvern,' Collingwood and Seymour-streets, Drummoyne. |
| 1882 | | Cornwell, Samuel, Australian Brewery, Bourke-st., Waterloo. |
| 1891 | | Coutie, W. H., M.B., Ch.B. *Melb.*, 'Warminster,' Canterbury Road, Petersham. |
| 1892 | P 1 | Cowdery, George R., Assoc. M. Inst. C.E., Engineer for Tramways, Phillip-st.; p.r. 'Glencoe,' Torrington Road, Strathfield. |
| 1886 | | Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 16 College-street, Hyde Park. |
| | | |
| 1905 | | Dampney, Gerald F., Fellow of the Society of Chemical Industry, 'Doonbah,' Hunter's Hill. |
| 1875 | | Dangar, Fred. H., c/o Messrs. Dangar, Gedye, & Co., Mercantile Bank Chambers, Margaret-street. |
| 1890 | | Dare, Henry Harvey, M.E., Assoc. M. Inst. C.E., Roads and Bridges Branch, Public Works Department. |
| 1876 | P 3 | Darley, Cecil West, M. Inst. C.E., 34 Campden Hill Court, Campden Hill Road, Kensington, London, W. |
| 1877 | | Darley, The Hon. Sir Frederick, G.C.M.G., B.A., Chief Justice, Supreme Court. |
| 1886 | P 18 | David, T. W. Edgeworth, B.A., F.G.S., F.R.S., Professor of Geology and Physical Geography, Sydney University, Glebe. |
| 1892 | P 1 | Davis, Joseph, M. Inst. C.E., Under Secretary, Department of Public Works. |
| 1885 | P 2 | Deane, Henry, M.A., M. Inst. C.E., Hoskins' Building, Spring-st.; p.r. 'Blanerne,' Wybalena Road, Hunter's Hill. |
| 1877 | | Deck, John Feild, M.D. Univ. *St. Andrews*, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 203 Macquarie-st.; p.r. 92 Elizabeth-st., Ashfield. |
| 1899 | P 1 | De Coque, J. V., c/o Messrs. Gibbs, Bright & Co., 37 Pitt-st. |
| 1894 | | Dick, James Adam, B.A., *Syd.*, M.D., C.M. *Edin.*, 'Catfoss,' Belmore Road, Randwick. |
| 1875 | P 12 | Dixon, W. A., F.C.S., Fellow of the Institute of Chemistry of Great Britain and Ireland, 97 Pitt-street. |
| 1880 | | Dixson, Thomas Storie, M.B. *Edin.*, Mast. Surg. *Edin.*, 287 Elizabeth-street, Hyde Park. |
| 1876 | | Docker, Ernest B., M.A. *Syd.*, District Court Judge, 'Eltham, Edgecliffe Road. |
| 1899 | | Duckworth, A., A.M.P. Society, 87 Pitt-st.; p.r. 'Trentham,' Woollahra. |
| 1873 | P 1 | Du Faur, E., F.R.G.S., 'Flowton,' Turramurra. |
| | | |
| 1879 | P 4 | Etheridge, Robert, Junr., J.P., Curator, Australian Museum; p.r. 21 Roslyn-street, Darlinghurst |
| 1876 | | Evans, George, Fitz Evan Chambers, Castlereagh-street. |
| 1904 | | Evans, James W., Chief Inspector, Weights and Measures; p.r. 'Glenthorne,' 4 Railway-street, Petersham. |

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| 1877 | | ‡Fairfax, Edward Ross, *S. M. Herald* Office, Hunter-street. |
| 1896 | | Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street. |
| 1868 | | Fairfax, Sir James R., Knt., *S. M. Herald* Office, Hunter-st. |
| 1887 | | Faithfull, R. L., M D., *New York* (Coll. Phys. & Surg.), L.R.C.P., L.S.A. *Lond.*, 18 Wylde-street. |
| 1902 | | Faithfull, William Percy, Barrister-at-Law, Australian Club. |
| 1897 | | Fell, David, M.L.A., C.A.A., Public Accountant, Equitable Building, George-street. |
| 1881 | | Fiaschi, Thos. M.D., M. Ch., *Pisa*, 149 Macquarie-street. |
| 1888 | | Fitzhardinge, Grantly Hyde, M A. *Syd.*, District Court Judge, 'Red Hill,' Beecroft, Northern Line. |
| 1900 | | ‡Flashman, James Froude, M.D. *Syd.*, Jersey Road, Burwood. |
| 1902 | | Fleming, Edward G., A.M.I.E.E., 16 O'Connell-street. |
| 1879 | | ‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R.C.P. *Edin.*. 141 Macquarie-st. |
| 1881 | | Foster, The Hon. W. J., K.C., 'Thurnby,' 35 Enmore Road, Newtown. |
| 1905 | | Foy, Mark, 'Eumemering,' Bellevue Hill, Woollahra. |
| 1904 | | Fraser, James, M. Inst. C.E., Engineer-in-Chief for Existing Lines, Bridge-street; p.r. 'Arnprior,' Neutral Bay. |
| 1899 | | French, J. Russell, General Manager, Bank of New South Wales, George-street. |
| 1881 | | Furber, T. F., F.R.A.S., 'Wavertree,' Kurraba Road, Neutral Bay. |
| | | |
| 1899 | | Garran, R. R., M.A., C.M.G., Commonwealth Offices, Spring-st., Melbourne. |
| 1876 | | George, W. R., 318 George-street. |
| 1879 | | Gerard, Francis, 'The Grange,' Monteagle, near Young. |
| 1896 | | Gibson, Frederick William, District Court Judge, 'Grasmere,' Stanmore Road. |
| 1859 | | Goodlet, J. H., 'Canterbury House,' Ashfield. |
| 1897 | | Gould, Major The Hon. Albert John, Senator, 'Eynesbury,' Edgecliffe. |
| 1891 | P 1 | Grimshaw, James Walter, M. Inst. C.E., M. I. Mech. E., &c., Australian Club. |
| 1899 | P 2 | Gummow, Frank M., M.C.E., Vickery's Chambers, 82 Pitt-st. |
| 1891 | P 11 | Guthrie, Frederick B., F.I C., F.C.S., Chemist, Department of Agriculture, 136 George-street, Sydney. *Vice-President.* |
| | | |
| 1880 | P 2 | Halligan, Gerald H., F G.S., 'Riversleigh,' Hunter's Hill. |
| 1899 | | Halloran, Aubrey, B.A., LL.B., Savings Bank Chambers, Moore-street. |
| 1892 | | Halloran, Henry Ferdinand, L.S., Scott's Chambers, 94 Pitt-st. |
| 1887 | P 7 | Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; Government Analyst, Health Department, Macquarie-street, North. |
| 1905 | P 1 | Harker, George, D. Sc., 35 Boulevarde, Petersham. |
| 1881 | | ‡Harris, John, 'Bulwarra,' Jones-street, Ultimo. |
| 1887 | P 18 | ‡Hargrave, Lawrence, Wunulla Road, Woollahra Point. |
| 1884 | P 1 | Haswell, William Aitcheson, M.A., D. Sc., F.R.S., Professor of Zoology and Comparative Anatomy, University, Sydney; p.r. 'Mimihau,' Woollahra Point. |

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| 1900 | | Hawkins, W. E., Solicitor, 88 Pitt-street. |
| 1890 | P 2 | Haycroft, James Isaac, M.E. Queen's Univ. *Irel.*, Assoc. M. Inst. C.E. Assoc. M. Cam. Soc. C.E., Assoc. M. Am. Soc. C.E., M.M. & C.E., M. Inst. C.E.I., L.S. 'The Grove,' off Queen-street, Woollahra. |
| 1891 | P 1 | Hedley, Charles, F.L.S., Assistant in Zoology, Australian Museum, Sydney. |
| 1900 | P 3 | Helms, Richard, Experimentalist, Department of Agriculture. |
| 1902 | | Hennessy, John Francis, Architect, Ashpitel Prizeman and Silver Medallist, Royal Institute of British Architects, City Chambers, 243 Pitt-street. |
| 1899 | | Henderson, J., F.R.E.S., Manager, City Bank of Sydney, Pitt-st. |
| 1899 | | Henderson, S., M.A., Assoc M. Inst. C.E., Equitable Building, George-street. |
| 1884 | P 1 | Henson, Joshua B., Assoc. M. Inst. C.E., Hunter District Water Supply and Sewerage Board, Newcastle. |
| 1904 | | Hill, John Whitmore, Architect, 'Willamere,' May's Hill, Parramatta. |
| 1876 | P 2 | Hirst, George D., F.R.A.S., 379 George-street. |
| 1896 | | Hinder, Henry Critchley, M.B., C.M. *Syd.*, Elizabeth-st., Ashfield. |
| 1892 | | Hodgson, Charles George, 157 Macquarie-street. |
| 1901 | | Holt, Thomas S., 'Holwood,' Victoria-street, Ashfield. |
| 1904 | | Holt, Rev. Wilfred John, M.A., 'Kiora,' Blackheath. |
| 1905 | | Hooper, George, Registrar, Sydney Technical College; p.r. 'Branksome,' Henson-street, Summer Hill. |
| 1905 | | Hoskins, George J., Burwood Road, Burwood. |
| 1891 | P 2 | Houghton, Thos. Harry, M. Inst. C.E., M. I. Mech. E., 63 Pitt-street. |
| 1894 | P 2 | Hunt, Henry A., F. R. Met. Soc., Acting Government Meteorologist, Sydney Observatory. |
| 1905 | | Hyde, Ellis, Analyst, 27 York-street. |
| | | |
| 1903 | | Irvine, R. F., M.A., Examiner for Public Service Board; p.r. Musgrave-street, Mosman. |
| | | |
| 1891 | | Jamieson, Sydney, B.A., M.B., M.R.C.S., L.R.C.P., 189 Liverpool-street, Hyde Park. |
| 1904 | | Jaquet, John Blockley, A.R.S.M., F.G.S., Acting Chief Inspector of Mines, Geological Surveyor, 'Cromer,' 91 Phillip-street. |
| 1900 | | Jarman, Arthur, A.R.S.M., Demonstrator in Assaying and Chemistry, University of Sydney. |
| 1903 | | Jenkinson, Edward H., M. I. Mech. E., 13 and 15 Macquarie Place. |
| 1904 | | Jenkins, R. J. H., Fisheries Commissioner, 'Pyalla,' 13A Selwyn street, Moore Park. |
| 1905 | P 2 | Jensen, Harold Ingemann, B. Sc., Macleay Fellow of the Linnean Society of New South Wales, Sydney University. |
| 1902 | P 1 | Jevons, H. Stanley, M.A. *Cantab.*, B. Sc., *Lond.*, University College of South Wales and Monmouthshire, Cardiff. |
| 1902 | | Jones, Henry L., Assoc. M. Am. Soc. C.E., 14 Martin Place. |
| 1884 | | ‡Jones, Llewellyn Charles Russell, Solicitor, Falmouth Chambers, 117 Pitt-street. |
| 1867 | | Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 16 College street, Hyde Park; p.r. 'Llandilo,' Boulevard, Strathfield. |

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| 1876 | P 2 | Josephson, J. Percy, Assoc. M. Inst. C.E., Stephen Court, 81 Elizabeth-street; p.r. 'Moppity,' George-street, Dulwich Hill. |
| 1878 | | Joubert, Numa, Hunter's Hill. |
| 1883 | | Kater, The Hon. H. E., J P., M.L.C., Australian Club. |
| 1873 | | Keele, Thomas William, M. Inst. C.E., President, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street. |
| 1887 | | Kent, Harry C., M.A., Bell's Chambers, 129 Pitt-street. |
| 1903 | P 1 | Kennedy, Thomas, Assoc. M. Inst. C.E., Railway Construction Branch, Public Works Department. |
| 1901 | | Kidd, Hector, M. Inst. C.E., 'Craig Lea,' 15 Mansfield-street, Glebe Point. |
| 1891 | | King, Christopher Watkins, Assoc. M. Inst. C.E., L.S., Assistant Engineer, Harbours and Rivers Department, Newcastle. |
| 1896 | | King, Kelso, 120 Pitt-street. |
| 1892 | | Kirkcaldie, David, Commissioner, New South Wales Government Railways, Sydney. |
| 1878 | | Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 1 Lyons Terrace, Hyde Park. |
| 1881 | P 17 | Knibbs, G. H., F.R.A.S., Memb. Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; 'Spottiswoode,' 28 Bland-street, Ashfield. *Hon. Secretary.* |
| 1877 | | Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay. |
| 1878 | | Kyngdon, F. B., F.R.M.S. *Lond.*, Deanery Cottage, Bowral. |
| 1874 | P 2 | Lenehan, Henry Alfred, F.R.A.S., Acting Government Astronomer, Sydney Observatory. *President.* |
| 1901 | | Lindeman, Charles F., Wine Merchant, Jersey Rd., Strathfield. |
| 1883 | | Lingen, J. T., M.A. *Cantab.*, 167 Phillip-street. |
| 1901 | | Little, Robert, 'The Hermitage,' Rose Bay. |
| 1872 | P 55 | Liversidge, Archibald, M.A. *Cantab.*, LL.D., F.R.S., Hon. F.R.S. *Edin.*, Assoc. Roy. Sch. Mines, *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chem. of Gt. Brit. and Irel., Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phy. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineralogical Society, *France*; Corr. Mem. Edin. Geol. Soc.; New York Acad. of Sciences; Roy. Soc., *Tas.*; Roy. Soc., *Queensland*; Senckenberg Institute, *Frankfurt*; Société d' Acclimat., *Mauritius*; Foreign Corr. Indiana Acad. of Sciences; Hon. Mem. Roy. Soc., *Vict.*; N. Z. Institute; K. Leop. Carol. Acad., *Halle a/s*; Professor of Chemistry in the University of Sydney, The University, Glebe; p.r. 'The Octagon,' St. Mark's Road, Darling Point. *Vice-President.* |
| 1884 | | MacCormick, Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 125 Macquarie-street, North. |
| 1887 | | MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 24 College-street. |
| 1892 | | McDonagh, John M., B.A., M.D., M.R.C.P. *Lond.*, F.R.C.S. *Irel.*, 173 Macquarie-street, North. |

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| 1897 | | MacDonald, C. A., C.E., 63 Pitt-street. |
| 1878 | | MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co. Ld., 2 Spring-street. |
| 1868 | | MacDonnell, William J., F.R.A.S., 4 Falmouth Chambers, 117 Pitt-street. |
| 1903 | | McDonald, Robert, J.P., Acting Under Secretary for Lands, p.r. 'Wairoa,' Holt-street, Double Bay. |
| 1891 | | McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H. *Cantab.*, Hospital for Insane, Gladesville. |
| 1904 | | MacFarlane, Edward, J.P., Under Secretary for Lands, 12 Fitzroy-street, Milson's Point, North Sydney. |
| 1891 | P 1 | McKay, R. T., C.E., 'Tranquilla,' West-street, North Sydney. |
| 1893 | | McKay, William J. Stewart, B.Sc., M.B., Ch.M., Cambridge-street. Stanmore. |
| 1876 | | Mackellar, The Hon. Charles Kinnaird, M.L.C., M.B., C.M. *Glas.*, Equitable Building, George-street. |
| 1904 | | McKenzie, Robert, Sanitary Inspector, (Water and Sewerage Board), 'Stonehaven Cottage, Bronte Road, Waverley. |
| 1880 | P 9 | McKinney, Hugh Giffin, M.E. Roy. Univ. *Irel.*, M. Inst. C.E., Exchange, 56 Pitt-street; p.r. 'Dilkhusha,' Fuller's Road, Chatswood. |
| 1903 | | McLaughlin, John, Solicitor, Clement's Chambers, 88 Pitt-st. |
| 1876 | | MacLaurin. The Hon. Sir Henry Normand, M.L.C., M.A., M.D, L.R.C.S. *Edin.*, LL.D. *St. Andrews*, 155 Macquarie-street. |
| 1901 | P 1 | McMaster, Colin J., Chief Commissioner of Western Lands; p.r. Wyuna Road, Woollahra Point. |
| 1894 | | McMillan, Sir William, 'Logan Brae,' Waverley. |
| 1900 | | MacTaggart, A. H., D.D.S. *Phil.* U.S.A., King and Phillip-sts. |
| 1899 | | MacTaggart, J. N. C., M.E, *Syd.*, Assoc. M. Inst. C.E., Water and Sewerage Board, 341 Pitt-street. |
| | | |
| 1882 | P 1 | Madsen, Hans F., 'Hesselmed House,' Queen-st., Newtown. |
| 1883 | P 15 | Maiden, J. Henry, J.P., F.L.S., Hon. Fellow Roy. Soc., S.A.; Hon. Memb. Nat. Hist. Soc., W.A.; Netherlands Soc. for Promotion of Industry; Philadelphia Coll. Pharm.; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc. Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin.; Soc. Nac. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat. etc. de Chérbourg; Roy. Soc., Tas.; Government Botanist and Director, Botanic Gardens, Sydney. *Hon. Secretary.* |
| 1880 | P 1 | Manfred, Edmund C., Montague-street, Goulburn. |
| 1897 | | Marden, John, B.A., M.A., LL.B. *Melb.*, LL.D. *Syd.*, Principal, Presbyterian Ladies' College, Sydney. |
| 1875 | P 20 | Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d' Anthrop. de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor. Mem. Anthrop. Soc. Vienna; Cor. Mem. Roy. Geog. Soc. Aust., Queensland; 'Carcuron,' Hassall-st., Parramatta. |
| 1903 | | Meggitt, Loxley, Manager Co-operative Wholesale Society, Alexandria. |
| 1896 | P 7 | Merfield, Charles J., F.R.A.S., Mitglieder der Astronomischen Gesellschaft, Observatory Sydney. |
| 1905 | | Miller, James Edward, Cobar. |

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| 1887 | | Miles, George E., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, The Hospital, Rydalmere, near Parramatta. |
| 1903 | | Minell, W. Percy, Incorporated Accountant, Martin Chambers, Moore-street. |
| 1889 | P 3 | Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines, Government Metallurgical Works, Clyde; p.r. Campbell-street, Parramatta. |
| 1879 | | Moore, Frederick H., Illawarra Coal Co., Gresham-street. |
| 1877 | | ‡Mullens, Josiah, F.R.G.S., 'Tenilba,' Burwood. |
| 1879 | | Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point. |
| 1887 | | Munro, William John, B.A., M.B., C.M., M.D. *Edin.*, M.R.C.S. *Eng.*, 213 Macquarie-street; p.r. 'Forest House,' 182 Pyrmont Bridge Road, Forest Lodge. |
| 1876 | | Myles, Charles Henry, 'Dingadee,' Burwood. |
| | | |
| 1893 | | Nangle, James, Architect, Australia-street, Newtown. |
| 1901 | | Newton, Roland G., 'Walcott,' Boyce-street, Glebe Point. |
| 1891 | | ‡Noble, Edwald George, Public Works Department, Newcastle. |
| 1873 | | Norton, The Hon. James, M.L.C., LL.D., Solicitor, 2 O'Connell-street; p.r. 'Ecclesbourne,' Ocean-street, Edgecliffe. |
| 1893 | | Noyes, Edward, Assoc. Inst. C.E., Assoc. I. Mech. E., c/o Messrs. Noyes Bros., 109 Pitt-street. |
| | | |
| 1903 | | Old, Richard, Solicitor, 'Waverton,' Bay Rd., North Sydney. |
| 1896 | | Onslow, Lt. Col. James William Macarthur, Camden Park, Menangle. |
| 1875 | | O'Reilly, W. W. J., M. D., M. Ch., Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 197 Liverpool-street, Hyde Park. |
| 1891 | | Osborn, A. F., Assoc. M. Inst. C.E., Public Works Department, Cowra. |
| 1883 | | Osborne, Ben. M., J.P., 'Hopewood,' Bowral. |
| 1903 | | Owen, Rev. Edward, B.A., All Saints' Rectory, Hunter's Hill. |
| | | |
| 1880 | | Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby. |
| 1878 | | Paterson, Hugh, 197 Liverpool-street, Hyde Park. |
| 1901 | | Peake, Algernon, Assoc. M. Inst. C.E., 25 Prospect Road, Ashfield. |
| 1899 | | Pearse, W., Union Club; p.r. Moss Vale. |
| 1877 | | Pedley, Perceval R., 227 Macquarie-street. |
| 1899 | | Petersen, T. Tyndall, Member of Sydney Institute of Public Accountants, Copper Mines, Burraga. |
| 1879 | P 6 | Pittman, Edward F., Assoc. R. S. M., L.S., Under Secretary and Government Geologist, Department of Mines. |
| 1896 | | Plummer, John, 'Northwood,' Lane Cove River; Box 413 G.P.O. |
| 1881 | | Poate, Frederick, Lands Office, Moree. |
| 1879 | | Pockley, Thomas F. G., Commercial Bank, Singleton. |
| 1887 | P 2 | Pollock, James Arthur, B.E. Roy. Univ. *Irel.*, B. Sc., *Syd.*, Professor of Physics, Sydney University. |
| 1896 | | Pope, Roland James, B.A. *Syd.*, M.D., C.M., F.R.C.S. *Edin.*, Ophthalmic Surgeon, 235 Macquarie-street. |

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| 1893 | | Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 'Valdemar,' Boulevard, Petersham. |
| 1901 | P 1 | Purvis, J. G. S., Water and Sewerage Board, 311 Pitt-street. |
| | | |
| 1876 | | Quaife, F. H., M.A., M.D., Mast. Surg. *Glas.*, 'Hughenden,' 14 Queen-street, Woollahra. *Vice-President.* |
| | | |
| 1899 | P 1 | Rae, J. L. C., 'Endcliffe,' Church-street, Newcastle. |
| 1902 | | Ramsay, Arthur A., Assistant Chemist, Department of Agriculture, 136 George-street. |
| 1904 | | Ramsay, David, Surveyor, 'Liryclea,' Lyons Road, Five Dock. |
| 1865 | P 1 | ‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S.E., F.L.S., 8 Palace-street, Petersham. |
| 1901 | | Raymond, Robert S., 'Yarroville,' Goulburn. |
| 1890 | | Rennie, George E., B.A. *Syd.*, M.D. *Lond*, M.R.C.S. *Eng.*, 159 Macquarie-street. |
| 1870 | | ‡Renwick, The Hon. Sir Arthur, Knt., M.L.C., B.A. *Syd.*, M.D., F.R.C.S. *Edin.*, 325 Elizabeth-street. |
| 1902 | | Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland. |
| 1903 | P 1 | Rooke, Thomas, A.M.I.C.E., Electrical Engineer, Town Hall, Sydney. |
| 1893 | P 1 | Roberts, W. S. de Lisle, C.E., 'Kenilworth,' Penshurst. |
| 1885 | | Rolleston, John C., Assoc. M. Inst. C.E., Harbours and Rivers Branch, Public Works Department. |
| 1892 | | Rossbach, William, Assoc. M. Inst. C.E., Chief Draftsman, Harbours and Rivers Branch, Public Works Department. |
| 1884 | | Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 147 Macquarie-st. |
| 1895 | P 1 | Ross, Herbert E., Consulting Engineer and Architect, Equitable Building, George-street. |
| 1904 | P 2 | Ross, William J. Clunies, B.Sc. *Lond. & Syd.*, F.G.S., Lecturer in Chemistry, Technical College, Sydney. |
| 1882 | | Rothe, W. H., Colonial Sugar Co., O'Connell-street, and Union Club. |
| 1864 | P 69 | Russell, Henry C., B.A. *Syd.*, C.M.G., F.R.S., F.R.A.S., F. R. Met. Soc., Hon. Memb. Roy. Soc. S. Australia, Sydney Observatory. |
| 1897 | | Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill. |
| 1893 | | Rygate, Philip W., M.A., B.E. *Syd.*, Assoc. M. Inst. C.E., Phœnix Chambers, 158 Pitt-street. |
| | | |
| 1905 | | Scheidel, August, Ph.D., Managing Director, Commonwealth Portland Cement Co., Sydney; Union Club. |
| 1899 | | Schmidlin, F., 83 Elizabeth-street, Sydney. |
| 1892 | P 1 | Schofield, James Alexander, F.C.S., A.R.S.M., University, Sydney. |
| 1905 | | Scott, Ernest Kilburn, The University, Sydney. |
| 1856 | P 1 | ‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights. |
| 1903 | | Scott, William B., Principal, Homebush Grammar School, p.r. Albert Road, Strathfield. |

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| 1877 | P 4 | Selfe, Norman, M. Inst. C.E., M. I. Mech. E., Victoria Chambers, 279 George-street. |
| 1904 | P 1 | Sellors, R. P., B.A. *Syd.*, 'Cairnleith,' Springdale Road, Killara. |
| 1891 | | Shaw, Percy William, M. Inst. C.E., Resident Engineer for Tramway Construction; p.r. 'Epcombs,' Miller-st. North Sydney. |
| 1883 | P 3 | Shellshear, Walter, M. Inst. C.E., Inspecting Engineer, Existing Lines Office, Bridge-street. |
| 1905 | | Simpson, D. C., Divisional Engineer, N. S. Wales Railways, Redfern; p.r. 'Omapere,' Lane Cove Road, North Sydney. |
| 1900 | | Simpson, R. C., Technical College, Sydney. |
| 1882 | | Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. Cleveland-street, Wahroonga. |
| 1893 | | Sinclair, Russell, M. I. Mech. E., etc., Consulting Engineer, Vickery's Chambers, 82 Pitt-street. |
| 1891 | P 3 | Smail, J. M., M. Inst. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street. |
| 1904 | P 1 | Smail, Herbert Stuart Inglis, B.E. *Syd.*, Bagan Serai, Federated Malay States. |
| 1893 | P 31 | Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney. |
| 1874 | P 1 | ‡Smith, John McGarvie, 89 Denison-street, Woollahra. |
| 1899 | | Smith, R. Greig, D. Sc. *Edin.*, M. Sc., *Dun.*, Macleay Bacteriologist, 'Otterburn,' Double Bay. |
| 1886 | | Smith, Walter Alexander, M Inst. C.E., Roads, Bridges and Sewerage Branch, Public Works Department; 12A Phillip-st. |
| 1896 | | Spencer, Walter, M.D. *Brux.*, 13 Edgeware Road, Enmore. |
| 1904 | | Stanley, Henry Charles, M. Inst. C.E., Royal Chambers, Hunter and Castlereagh-streets. |
| 1892 | P 1 | Statham, Edwyn Joseph, Assoc. M. Inst. C.E., Cumberland Heights, Parramatta. |
| 1900 | | Stewart, J. D., M.R.C.V.S., Government Veterinary Surgeon, Department of Mines and Agriculture; p.r. Cowper-street, Randwick. |
| 1903 | | Stoddart, Rev. A. G., The Rectory, Manly. |
| 1883 | P 3 | Stuart, T. P. Anderson, M.D., LL.D. *Edin*, Professor of Physiology, University of Sydney; p. r. 'Lincluden,' Fairfax Road, Double Bay. |
| 1901 | P 1 | Süssmilch, C. A., Technical College, Sydney. |
| | | |
| 1905 | | Taylor, John M., M.A., LL.B. *Syd.*, 'Eastbourne,' Alfred-street, North Sydney. |
| 1893 | | ‡Taylor, James, B. Sc., A.R.S.M., Nymagee. |
| 1899 | | Teece, R., F.I.A., F.F.A., General Manager and Actuary, A.M.P. Society, 87 Pitt-street. |
| 1861 | P 19 | Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales. |
| 1896 | | Thom, James Campbell, Solicitor, 'Dunoon,' Eurella-street, Burwood. |
| 1896 | | Thom, John Stuart, Solicitor, Athenæum Chambers, 11 Castlereagh-street. |
| 1878 | | Thomas, F. J., Newcastle and Hunter River Steamship Co., 147 Sussex-street. |
| 1879 | | Thomson, Dugald, M.H.R., 'Wyreepi,' Milson's Point. |

| Elected | | |
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| 1885 | P 2 | Thompson, John Ashburton, M.D. *Brux.*, D.P.H. *Cantab.*, M.R.C.S. *Eng.*, Health Department, Macquarie-street. |
| 1896 | | Thompson, Capt. A. J. Onslow, Camden Park, Menangle. |
| 1892 | | Thow, William, M. Inst. C.E., M. I. Mech. E., Locomotive Department, Eveleigh. |
| 1894 | | Tidswell, Frank, M. B., M. Ch., D P.H. *Cantab.*, Health Department, Sydney. |
| 1894 | | Tooth, Arthur W., Kent Brewery, 26 George-street, West. |
| 1879 | | Trebeck, P. C., F. R. Met. Soc., 12 O'Connell-street. |
| 1900 | | Turner, Basil W., A.R.S.M., F.C.S., Wood's Chambers, Moore-st. |
| 1905 | | Turner, John William, Assistant Under Secretary, Department of Public Instruction, Sydney. |
| | | |
| 1883 | | Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe. |
| 1884 | | Verde, Capitaine Felice, Ing. Cav., viâ Fazio 2, Spezia, Italy. |
| 1890 | | Vicars, James, M.C.E., M. Inst. C.E., City Surveyor, Adelaide. |
| 1892 | | Vickery, George B., 78 Pitt-street. |
| 1903 | P 1 | Vonwiller, Oscar U., B. Sc., Demonstrator in Physics, University of Sydney. |
| 1876 | | Voss, Houlton H., J.P., c/o Perpetual Trustee Company Ld., 2 Spring-street, |
| 1904 | | Vogan, Harold Sebastian, Assoc. M. Inst. C.E.. Authorised Surveyor N.Z., Chief Draftsman, Existing Railways N.S.W., Bridge-st. |
| | | |
| 1898 | P 1 | Wade, Leslie A. B., Assoc. M. Inst. C.E.. Department of Public Works |
| 1879 | | Walker, H. O., Commercial Union Assurance Co., Pitt-street. |
| 1899 | | ‡Walker, Senator J. T., 'Rosemont,' Ocean-street, Woollahra. |
| 1901 | | Walkom, A. J., A.M.I.E.E., Mem. Elec. Assoc. N.S.W., Electrical Branch, G.P.O. Sydney. |
| 1900 | | Wallach, Bernhard, B.E. *Syd.*, Electrical Engineer, 'Oakwood,' Wardell Road, Dulwich Hill. |
| 1891 | | Walsh, Henry Deane, B.E., T.C. *Dub.*, M. Inst. C.E., Engineer-in-Chief, Harbour Trust, Circular Quay. |
| 1903 | | Walsh, Fred., George and Wynyard-streets ; p.r. 'Walworth,' Park Road, City E. |
| 1901 | | Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi. |
| 1898 | | Wark, William, 9 Macquarie Place ; p.r. Kurrajong Heights. |
| 1877 | | Warren, William Edward, B.A., M.D., M. Ch., Queen's University *Irel.*, M.D. *Syd.*, 283 Elizabeth-street, Sydney. |
| 1883 | P 16 | Warren, W. H., Wh. Sc., M. Inst. C.E., Professor of Engineering, University of Sydney. *Vice-President.* |
| 1876 | | Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman, Attorney General's Department, Macquarie-st. |
| 1876 | | Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville Road, Newtown. |
| 1897 | | Webb, Frederick William, C.M.G., J.P., 'Livadia,' Manly. |
| 1903 | | Webb, A. C. F., Consulting Electrical Engineer, Vickery's Chambers, 82 Pitt-street. |
| 1892 | | Webster, James Philip, Assoc. M. Inst. C.E., L.S., *New Zealand*, Town Hall, Sydney. |
| 1867 | | Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master, Sydney Grammar School, College-street. |

| Elected | | |
|---|---|---|
| 1902 | | Welsh, David Arthur, M.D., M.A., B.Sc., Professor of Pathology, Sydney University, Glebe. |
| 1881 | | ‡Wesley, W. H. |
| 1879 | | ‡Whitfeld, Lewis, M.A. *Syd.*, 'Glencoe,' Lower Forth-street, Woollahra. |
| 1892 | | White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn. |
| 1877 | | ‡White, Rev. W. Moore, A.M., LL.D., T.C.D. |
| 1883 | | Wilkinson, W. Camac, M.D. *Lond.*, M.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 213 Macquarie-street. |
| 1876 | | Williams, Percy Edward, Comptroller, Government Savings Bank, Sydney. |
| 1901 | | Willmot, Thomas, J.P., Toongabbie. |
| 1878 | | Wilshire, James Thompson, F.R.H.S., J.P., 'Coolooli,' Bennet Road, Neutral Bay. |
| 1879 | | Wilshire, F. R., Police Magistrate, Penrith. |
| 1890 | | Wilson, James T., M.B., Master Surgeon, *Edin.*, Professor of Anatomy, University of Sydney. |
| 1873 | | Wood, Harrie, J.P., 10 Bligh-st.; p.r. 54 Darlinghurst Road. |
| 1891 | | Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield. |
| 1876 | P 1 | Woolrych, F. B. W., 'Verner,' Grosvenor-street, Croydon. |
| 1902 | | Wright, John Robinson, Lecturer in Art, Technical College, Harris-street, Sydney. |
| 1879 | | Young, John, 'Kentville,' Johnston-street, Leichhardt. |

## Honorary Members.

*Limited to Thirty.*

M.—Recipients of the Clarke Medal.

| | | |
|---|---|---|
| 1901 | | Baker, Sir Benjamin, K.C.M.G., D.Sc., LL.D., F.R.S., etc., 2 Queen Square Place, London, S.W. |
| 1875 | | Bernays, Lewis A., C.M.G., F.L.S., Brisbane. |
| 1905 | | Cannizzaro, Stanislao, Professor of Chemistry, Reale Università Rome. |
| 1900 | | Crookes, Sir William, F.R.S., 7 Kensington Park Gardens, London W. |
| 1875 | M | Ellery, Robert L. J., F.R.S., F.R.A.S., c/o Government Astronomer of Victoria, Melbourne. |
| 1905 | | Fischer, Emil, Professor of Chemistry, University, Berlin. |
| 1887 | | Foster, Sir Michael, M.D., F.R.S., Professor of Physiology, University of Cambridge. |
| 1875 | P 1 M | Hector, Sir James, K.C.M.G., M.D., F.R.S., late Director of the Colonial Museum and Geological Survey of New Zealand, Wellington, N.Z. |
| 1880 | M | Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., c/o Director of the Royal Gardens, Kew. |
| 1892 | | Huggins, Sir William, K.C.B., D.C.L., LL.D., F.R.S., &c., 90 Upper Tulse Hill, London, S.W. |
| 1901 | | Judd, J. W., C.B., F.R.S., F.G.S., Professor of Geology, Royal College of Science, London. |

| Elected | | |
|---|---|---|
| 1903 | | Kelvin, Right Hon. William Thomson, Lord, O.M., G.C.V.O., D.C.L., LL.D., F.R.S., etc., 15 Eaton Place, London, S.W. |
| 1903 | | Lister, Right Hon. Joseph, Lord, O.M., B.A., M.B., F.R.C.S. D.C.L., F.R.S., etc., 12 Park Crescent, Portland Place, London, W. |
| 1901 | | Newcomb, Professor Simon, LL.D., Ph. D., For. Mem. R.S. Lond., United States Navy, Washington. |
| 1905 | | Oliver, Daniel, LL.D., F.R.S., Emeritus Professor of Botany, University College, London. |
| 1894 | | Spencer, W. Baldwin, M.A., C.M.G., F.R.S., Professor of Biology, University of Melbourne. |
| 1900 | M | Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., B.Sc. F.R.S., F.L.S., Director, Royal Gardens, Kew. |
| 1895 | | Wallace, Alfred Russel, D.C.L. *Oxon.*, LL.D. *Dublin*, F.R.S., Old Orchard, Broadstone, Wimborne, Dorset. |

## Obituary 1905.

*Honorary Members.*

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|---|---|---|
| 1875 | | Gregory, The Hon. Sir Augustus Charles. |
| 1888 | | Hutton, Captain Frederick Wollaston. |

*Ordinary Members.*

| | | |
|---|---|---|
| 1878 | | Dean, Alexander |
| 1877 | | Hume, J. K. |
| 1877 | | Keep, John |
| 1856 | | Moore, Charles |
| 1877 | | Perkins, Henry A. |
| 1897 | | Portus, A. B. |

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## AWARDS OF THE CLARKE MEDAL.

Established in memory of

The late Revd. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

*Vice-President from* 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia.

1878 Professor Sir Richard Owen, K.C.B., F.R.S., Hampton Court.

1879 George Bentham, C.M.G., F.R.S., The Royal Gardens, Kew.

1880 Professor Thos. Huxley, F.R.S., The Royal School of Mines, London. 4 Marlborough Place, Abbey Road, N.W.

1881 Professor F. M'Coy, F.R.S., F.G.S., The University of Melbourne.

1882 Professor James Dwight Dana, LL.D., Yale College, New Haven, Conn., United States of America.

1883 Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S. Government Botanist, Melbourne.

1884 Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S., Director of the Geological Survey of Canada, Ottawa.

1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.

1886 Professor L. G. De Koninck, M.D., University of Liège, Belgium.

1887 Sir James Hector, K.C.M.G., M.D., F.R.S., Director of the Geological Survey of New Zealand, Wellington, N.Z.

1888 Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Sydney.

1889 Robert Lewis John Ellery, F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

1890 George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S., William Street, Sydney.

1891 Captain Frederick Wollaston Hutton, F.R.S., F.G.S., Curator, Canterbury Museum, Christchurch, New Zealand.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., Director, Royal Gardens, Kew.

1893 Professor Ralph Tate, F.L.S., F.G.S., University, Adelaide, S.A.

1895 Robert Logan Jack, F.G.S., F.R.G.S., Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Government Palæontologist, Curator of the Australian Museum, Sydney.

1896 Hon. Augustus Charles Gregory, C.M.G., M.L.C., F.R.G.S., Brisbane.

1900 Sir John Murray, Challenger Lodge, Wardie, Edinburgh.

1901 Edward John Eyre, Walreddon Manor, Tavistock, Devon, England.

1902 F. Manson Bailey, F.L.S., Colonial Botanist of Queensland, Brisbane.

1903 Alfred William Howitt, D. Sc. *Cantab.*, F.G.S., Hon. Fellow Anthropol. Inst. of Gt. Brit. and Irel., 'Eastwood,' Bairnsdale, Victoria.

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## AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

*Money Prize of £25.*

1882 John Fraser, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

*The Society's Bronze Medal and £25.*

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney for paper on 'The Tin deposits of New South Wales.

1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper on 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper on 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper on the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper on 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, B.Sc., M.B. *Lond.*, Sydney, for paper on 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper on 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

# PRESIDENTIAL ADDRESS.

By C. O. BURGE, M. Inst. C.E., Telford Medallist, Inst. C.E.

[*Read before the Royal Society of N. S. Wales, December 7, 1904.*]

As to the main subject of my address, I have been confronted with the usual difficulty of choosing it. Ordinarily, the annual address has been either a resumé, during a definite period, of the work of science generally, or of that section of it with which the avocations of the particular president befits him best to deal. The first method necessarily involves a good deal of second hand information, given by one who is necessarily not an expert in all, and as it is, of course, a large subject, dealt with in a comparatively small space, it must be scrappy and unsatisfactory. Such a treatment of the subject would be like the discharge from an ancient bell mouthed blunderbuss, which scatters all round, but hits nobody very effectively. The alternative of dealing with the president's own speciality may be compared to the bullet from the modern rifle, which deals with one object effectively, but leaves the rest untouched. Such special subjects had best be left to the annual addresses of the chairmen of the Sections of this Society, which its hospitable policy throws open to all branches of science.

Between this Scylla and Charybdis, however, there is a middle course, which, unlike such generally, is not a weak one, owing to two recent facts to which I shall presently refer. The subject I have chosen is the connexion between Engineering and Science, as a whole, and the two facts just mentioned which have brought this connexion into prominence, are firstly, the establishment of examinations in scientific subjects, by the Institution of Civil Engineers, as a condition of entry, and secondly, the cordial recognition

by this Society, which is the chief and oldest representative of science in Australasia, of engineering as one of its branches, emphasized by the fact of the election to the high office of President, of two engineers previously, and now a third, in my own person.

In the earlier ages, we may surmise, that the connexion, which is the subject of this address, was closer than in later times, for though, as regards the great ancient engineering works now extant in Egypt, and throughout the Roman Empire, the names of the designers are, to a large extent lost, we may yet be fairly sure that, it being before the age of specialism, the science of engineering, necessary for those monuments of human skill, were concentrated in the same individuals. As scientists whose theories helped engineering in the classic period, might be mentioned Thales, Anaxagoras, Ptolemy, Euclid, Hipparchus, Appolonius, but above all, Archimedes.

After the work of the Ancients, we find that of the Moors of Spain, prominent in this connection, as illustrated by the survival of several scientific terms such as algebra and chemistry, which are Arabic in origin. Leonardo da Vinci, whose fame as an artist makes us forget that he was also a scientist and engineer, treated of the laws of motion, before the end of the 15th century, though his works were not printed till 100 years later. Euclid was translated from the Greek early in the 16th century, and Cardan and Tartaglia, in the same age, became the founders of the higher algebra. An Englishman, Robert Record, invented, in 1557, the signs since used for plus and minus, and the two parallel horizontal lines for equality, and though this seems to us a small thing, we must remember that facilities of this sort were no trifles, in the birth of the science.

Astronomy, in its help to geodesy, has had much to do with engineering, so that Copernicus can hardly be left out

in a summary of this kind, nor can we forget Tycho Brahe in his self exile for 20 years, in his lonely Baltic isle, and his observations there, unassisted as he was, by modern telescopes.

Cardan and Tartaglia, already mentioned, as well as Ubaldi, may be said to have created the science of mechanics, which has, more than any other, helped engineering, while the great name of Galileo, who for versatility of genius, is one of the greatest of human names, advanced it largely by his experiments in statics and dynamics, and in the invention of the telescope. It was finely said of him, at the time, that by this feat, he had seen more than all the eyes that had gone before, and had opened the eyes of all that were to come after him.

Hydrostatics, which, with hydraulics, governs the operations of water supply and sewerage engineering, and in which no advance had been made since the time of Archimedes, was investigated in the same century by Stivinius, and from William Gilbert, an Englishman of Queen Elizabeth's reign, we have a Latin treatise on the magnet, in which the dawn of electrical science is dimly perceived, and in which so little was done, since, up to the middle of the last century.

But all this had no interest for the constructing engineers, or mechanics, as they were then called, of that time. The great rule of thumb reigned supreme and undisputed. Francis Bacon, in his *Filum labyrinthi*, wrote, "The mechanics take small light from natural philosophy, and do but spin on their own little threads," and the reproach, in which his far-seeing intellect is well shewn, might have been justified for many generations after him.

James Watt, notably, and some others in the early days of modern engineering, did, undoubtedly, bring the dim lamp of the science of their day to light up their work, but

many ignorant men relied on their native wit, and practical experience, to achieve results which, though wonderful, as operations in the dark, would have been so much better, if their earlier training had led them to ask for the illuminating aid of science.

Many a laborious scientific investigation of the present day, is looked upon as only abstractedly interesting, and of no practical advantage outside the walls of an institution like this in which we meet, and it is thought that money spent upon it is taken from some more practical immediate use. So said the so-called practical men of 300 years ago. Now we know how grievously they were mistaken, and how the Merry Monarch, who is said to have never said a foolish thing, nor done a wise one, certainly did a wise thing, in founding our great parent, the Royal Society of London, to which is due so much of the practical science of the last two centuries.

The Elizabethan mechanics knew not of their great contemporary Napier of Merchistoun, who, by his invention of logarithms, has so greatly lightened the labours, not only of the astronomer and through him, the navigation of the world, but also those of the engineering designer. Indeed without Napier's aid, the vast work of these callings, at the present day, would be impossible. Though hinted at by an earlier German writer, Michael Stifelius, this invention of the 17th century was undoubtedly one of the greatest intellectual feats of the human mind, and it is remarkable in having issued complete, like the birth of Pallas Athene, ready armed and equipped, from the author's brain, and it has not received any material improvement since. Nor were the mechanics and millwrights of succeeding generations more aware of the scientific achievements, affecting their work, of Kepler, Galileo, Cavalieri, Harriott, Descartes, Newton and others, in conic sections, algebra and mensur-

ation, as well as in statics and dynamics. Later, it was due solely to the conceptions of Joseph Black, chemist, physician, and professor, in Glasgow and Edinburgh, as to the action of pressure on boiling point, and absorption of heat by vapour, that James Watt was enabled to effect a revolution in the construction of the steam engine.

Pambour, Eaton Hodgkinson, Clerk Maxwell, Kelvin, and Lodge, with many others, have more recently contributed to the achievements of the engineer.

In the last half of the century just passed, however, the tendency of the education of the engineer being undertaken by technical institutions, rather than by the older pupilage system, has, so to say, married engineering to science. It has been truly a marriage at a mature age, but now that the parties to it are old enough to know their own minds, surely it is a love match, which is being blessed with an ample progeny.

The Odyssey of Homer is considered by some authorities to have been written solely as an allegory of man's life through this world of temptations and dangers, and of his protection from them by the heavenly powers. The tale of the great hero Odysseus, in his temptations by Circe and Calypso, his struggles with the monster Polyphemus, and the loosening of the windbag of Æolus, but ever helped by the divine influence of the goddess of Wisdom, to the arms of the faithful Penelope, personifies the life of every man, through his mortal existence here on earth. As to the windbag, we have in the present day, unlettered and small knowing souls, as Shakespeare calls them, who loosen on us many windbags, which waste our energies for real advancement, as the reporting columns of our newspapers shew, and who, one would almost think, were within the prophetic insight of old Homer when he composed the allegory. May we not take this wonderful story of old,

more vivid and entertaining than any novel written since, as an illustration of our subject. Odysseus, working onward to his goal, but, even though he is called the man of many devices, the engineer of his age, blindly falling into difficulties, often of his own making, nevertheless ever rescued and sustained by the fair goddess of all science, the grey eyed Athene.

The fairy tales of science may well be read for their own sweet sake, but when studied with a utilitarian end in view as in connexion with our subject, they have also their absorbing interest. Huxley's definition of science was "Organized Common Sense," but though true, this does not strike one as sufficiently distinctive, as this should describe other subjects with which science has nothing to do. The latter has one great distinction from those three other subjects which so largely employ the human mind, law, literature and art, that is the distinction of originality. Law is chiefly made up of precedents; listen to the finest poetry of modern times, and, in the ears of those who remember the ancient classics, familiar echoes are constantly ringing; in the great library of the British Museum and in the Bibliothèque Nationale of Paris, we see crowds of persons, called by courtesy, authors, constantly making new books out of old ones. These are the importers and retail tradesmen, not the producers of thought. A great Elizabethan writer speaks of books as "Ships passing through the vast seas of time, and making ages so distant, to participate of the wisdom, the one of the other." But he had only in view the classics of old, not those numerous worthless productions of to day which might be fitly compared to frail craft launched forth, to be wrecked on the shores of time, through their own weakness and instability. Greece and the middle ages have exhausted our ideas in art and architecture, and the invention of a new archi-

tectural style seems to be only a vision of despair—all is imitation, which though it may be the best flattery, is undoubtedly the confession of mediocrity. Not so in science. The galaxy of its brilliant originators still shine supreme in the great heaven of scientific discovery, and periodically there gleams from it some bright particular star, leading us to some epoch making achievement in the betterment, and in the progress, of mankind.

The discovery of the secrets of nature are generally individualistic, and lead to the laws of nature, laws which are interpreted by the scientist and regulated in their action, to benefit of mankind, by the surgeon, the navigator, but above all, by the engineer. The discoverer, the scientist, and the executant, this great trinity, is necessary for the physical well being of the world. In this music of the spheres, we must have the inventor of the principles of harmony, the composer to apply them, and the performer to delight our ears and our intellect.

The absolute necessity of the man of science to modern life, has recently been well illustrated by the production of an amusing comedy, where, among a party cast on a desert island, he, alone, who knows, is king. Rank, and worth in other respects, have to go under. The man who can, from his knowledge, create, he who holds command of the sources of material existence, he it is who leads the party; to rebel against him would mean misery and starvation. The greater part of the material, and not a little of the moral, progress of the world is due to the scientist and the engineer. They have lightened the tasks of life, and enabled men to find leisure from the drudgery of the mere struggle for existance. In the days of the spinning wheel, the hand-loom, and the carrier's waggon, the poor man's cottage was the scene of perpetual toil, even the small children had to work, with no time for

education or self improvement. It was only when the steam engine spread over sea and land, enabling one man to do the work of many, that mental and bodily comfort was attainable. It is the universal experience that, as machinery advances, not only wages, but the purchasing power of wages, rise, and with them the standards of life. A recent writer says that most people would resent it, as a bad joke, if told that the steam engine was the author of their being, and that they were more nearly related to it than to their uncles and aunts. Yet were it not for the machines worked by steam, probably more than half of us would never have existed.

Yet, among the young men of our day what are the names of Kelvin, of Lodge, of Rayleigh, of Dewar, and others, beside that of a famous cricketer, or of the man who can kick a ball further and straighter than another? We may allow that mental culture cannot stand alone, it must be the outcome of sufficient physical training. The old maxim "Mens sana in corpore sano," is ever true, but are we not overloading the latter part of the prescription? The traditional Irishman is sneered at for regarding fighting as an end, and not a means, but are not the Australians earning the reputation of confounding means and ends, in an even more absurd way? The combination is as old as Plato, who laid down music and gymnastics as the twin bases of education, the word Μουσική, of course, including all art and literature, but the gymnastics were regarded as means only, for the double purpose of efficiency in war, and for the training of the body, so that it should be intellectually vigorous.

The man of science is unappreciated, because his gifts are unsought, and when conferred, are rapidly rendered commonplace by constant use, and often that use does not become available for some years after the invention has

left the author's brain. Till we get proper appreciation of scientific work, or are rudely awakened from self complacency by some crushing loss in trading, or in war, we shall not see the urgency of arming our citizens, in the great rivalry of nations, with better technical education. If the money spent on this in the British Empire were equal to that in Germany, we should hear no complaints of threatened loss of commercial supremacy. Professor Perry, indeed, recently proposed that £1,000,000 be granted by the British Government to encourage men of science to devote their energies to the increase of efficiency in the steam engine, and to the great economy of fuel, which forms so large a portion of the national assets, and if we could induce some foreign nations to dump down, on our shores, some of that common sense which guides them in such matters, it would be well for us here in Australia, as well at at home.

There is no doubt that we want more and better technical education in the Colonies. Progress has been made in this in Europe and America, and more especially in Germany, to which is probably owing the fact that, according to recent statistics, the original scientific papers published in that country, amount in number up to date, to 43% of the whole of those of the world. While the male population of Germany increased from 1870 to 1900, by 40%, the students at universities and technical colleges increased by 164%; but it is not the provision of educational means which is enough, we must have the desire to use them, as indicated by these German figures. It has been well said that the question is not whether a man has gone through the university, it is whether the university has gone through him. Training in habits of exact observation and intelligent inference is wanted, not that interest which is expressed by the observation of a man of unscientific temperament,

who once spoke of a proposition in Euclid, as a happy ending to a mildly exciting plot. At the same time, it must not be forgotten that technical education is for the selected few, not for all, and the selection is a matter of great importance. For the average child's skull is not, as some educationalists seem to think, constructed of india rubber, into which unlimited quantities of knowledge can be thrust. The Japanese understand this, in selecting boys from the lower schools, for the higher, and then again from the higher for special attention, either by sending them abroad at Government expense, or otherwise, and leaving the dull ones to be the hewers of wood and drawers of water.

One of the most curious features of scientific history is the fact that the Anglo Saxon race, in the Empire and in the United States, has been always preeminent in original invention, while, latterly, the Germans have been more assiduous and painstaking in that education, which brings out the value of the scientific progress, which the inventions of others produce, and the same is due of other branches of human thought. It was the English Francis Bacon that said "knowledge is power," but it is the German of to-day who most realizes and profits by that weighty and now obvious aphorism. It was the English Shakespeare who wrote the mightiest plays; it is at Berlin where they are chiefly acted and appreciated. When I was there recently, two of his plays were running, and at the same time in London, which is nearly three times as populous, there was not one.

Notwithstanding the neglect, until latterly, of science in engineering, great strides have been taken, perhaps the greatest, in recent times, have been in connexion with light; mechanical contrivances and energy, through the medium of electricity; and the disposal of the refuse of cities. As to light, there is a question which is more one

for the anatomist than the engineer, whether the human eye is developing the power to withstand, without injury, the intense brightness provided by modern electrical and gas engineers, for the aim seems to be, not the same light at less expense, but increased light even at increased expense. Some of the old and widely read books of 300 years ago, such as the first English Bibles, which must have been largely read by rushlights and without spectacles, are of such small print as to tax our eyes even now with this aid, and by modern lights. I remember, when I first visited Paris, nearly 40 years ago, one of the first impressions received was being almost dazzled by the brilliancy of the street lamps and shop lights, yet they consisted of the now despised dull yellow gas jets. In those days, spectacles on children were absolutely unknown.

Electricity has been said to be the most versatile and controllable means of conveying power yet discovered by man, and, in each phase of its activity, it represents an advance in the conquest of nature by means of its own laws, and by bending its forces to the improvement of all conditions of life. What that advance has been, is shewn by the fact that in the United Kingdom in 1896, 1901, and 1903, there were sold respectively 30, 110, and 345 millions of B.T. units, all this being due, primarily, to the scientists, from the humble beginnings of the Elizabethan William Gilbert, to the brilliant but more specialized men of the present age.

Chemical welding is a notable instance of quite recent adoption, where science has had the chief part, in an engineering contrivance of great value and widespread use.

The compounding of steam engines, and the improvements in the turbine, have gone a long way towards economy in mechanical power, where they are applicable, and especially in the latter, in reducing weight and vibration, as well as superintendence.

In gas engineering, both as regards light, heat, and power, the Welsbach and Mond systems have shewn what may be done by healthy rivalry.

The improved treatment of sewage of late years, in conjunction with bacteriology, has no doubt saved an enormous number of lives, valuable, and otherwise. Then the analyst has rendered incalculable service to the engineer, in investigating the properties of materials, and in the adjustment of them to the requirements of his art—quite a modern combination.

In this summary, and it would be the same, if treating of literature, one thing strikes us, that is when we consider the slight foundations on which they had to build, that the great men of old stand high in the background of the mental landscape of the past, while the foreground of the present is comparatively paltry and insignificant. It would seem as if nature had furnished a constant average amount of original intellect, in equal periods of time, and that, though population increases largely, that great gift does not increase with it, but is, through education, spread over a larger number of individuals, tending, in the far future, to a hopeless and uninteresting universal mediocrity. In this future democracy of brains, one man will, intellectually, be no better than another. Plato is said to have made havoc among our originalities, but without going so far as this, we may allow that the subtle fluid of original genius is gradually becoming rarified into a sort of cerebral hydrogen, so to say, in its enormous distribution. To this is due, that, in the later sciences, electricity for example, we can point to few great outstanding figures. Invention has been piecemeal.

So much for the past. Now for the future. Carlyle truly says:—"The man who cannot wonder, were he President of innumerable Royal Societies, and carried the whole

"Mécanique Céleste," and "Hegel's Philosophy," and the epitome of all laboratories and observatories, with their results, in his single head, is but a pair of spectacles, behind which there is no eye." Let me not, as one of those presidents, come under this withering condemnation, but proceed to wonder what will come next, as the fruits of science and engineering, no matter how unsuccessful I may be. The field is great, the secrets of nature, still to be solved, are inexhaustible, an ever larger and larger number of fertile brains are continuously at work, in discovery and invention, as the various patent offices shew; and these fresh brains start from an ever widening vantage ground of accumulated research and experience, which was absent in a great measure, as a support, to the giants of science and engineering of the old time.

First in importance, perhaps, though owing to practical difficulties, still far off, is the conversion of the working of our main line railways to traction by means of electricity, in which great force of nature, the physicist has inspired the engineer. In this application of it, it is to be hoped that the initial mistake of placing power houses in wrong sites will be avoided. It is well to remember that the electric fluid can be conveyed cheaper than coal, within limits, so that the power should originate near the coal mine. The old proverb, of the uselessness of sending coals to Newcastle, must take the form, rather, of the waste of carrying them away from such great sources of supply. Electricity, applied to long distance railway traffic, may also relieve us of the waste now going on, by which over 200 tons of train are moved, in order to carry 2 or 3 tons of passengers. Greater separation must also be made between express train service, and that of the slower passenger and goods. It was stated recently that, on the Midland Railway of England, a large proportion of the

14,000,000 annual train miles of shunting, was incurred to clear the line for expresses. Hence we may expect to see, as the first development, the establishment of special lines, more or less parallel to the existing main ones, for fast traffic only, worked by the latest electrical methods. As to suburban traffic, the nature of the new means of power, points to the adoption of uniform short intervals between trains, all day, the variation in traffic being met by increasing and diminishing the number of cars in each of the trains rather than their frequency, most of the cars being self-propelling. The enormous amount of the rolling stock, which would be rendered useless by the change to electricity is certain to be a great obstacle to it, and as this will make the change gradual, the evils of piecemeal installation can hardly be avoided.

It may not be generally known that, as far back as in the book of Job, Chap. xxxviii., v. 35, we have an allusion to wireless telegraphy. This is now, after so many ages, an accomplished fact, but there are also now promises of the most wonderful character, through the investigations of Tesla and others, as to the transmission, by electricity without wires, of power, the possibilities of which it is difficult to foresee. That, by the mysterious power of an intangible and invisible agency, great machinery, thousands of miles away, can be driven without visible connexion, is stimulating to the imagination in the highest degree. We seem to be peeping into the coming wireless age, when man will be, more and more, Lord of the Creation, and when the vassals of his intellect will come, at his beck and call, to provide for wants and comforts, hitherto either unknown, or furnished by the bodily toil of his fellow man.

Next, it is almost certain that the adoption of wide and straight streets in large cities, will be a work of the future, even at the cost of much reconstruction, so as to enable

the tram and motor car to expel altogether the more costly horse, which is slow and dirty. In crowded London, the omnibus and its horses scarcely utilize half the space they occupy, and it takes 50 minutes to crawl from the nearest residential parts, to the city. By combined extra speed and economy of space, the same business could be done by electric tram cars and motor cars, at much less cost and crowding if the streets were suitable. The horses in our streets are a continual offence to sanitation, and cause great expense in street maintenance, which would largely disappear if traffic were mechanical only, altogether independently of the great reduction in the cost of traction, for the same results. It is to be hoped that, in fixing the site for the Commonwealth city, within the Federal area, due attention will be given to the importance of level ground, which bears so much on this matter.

In an earlier part of this address, allusion was made to a proposal, that a million of money should be an endowment of research, as regards increased economy in dealing with the application of heat to mechanical power. It is humiliating to reflect on what a small percentage of the energy of fuel reaches its ultimate work, or what is called the Brake Horse Power. The turbine, and various forms of internal combustion engines, show better results than the ordinary reciprocating steam engines, and, as it is never too late to mend, and always too soon to despair, we may look to the science of the future, to save our rapidly diminishing fuel supply, in this matter.

It may be thought that the application of the various means of mechanical power to such an apparently insignificant matter as domestic service, is beneath the dignity of science or engineering, but when we consider how many families keep, at least, one servant, who might be doing useful work elsewhere, the question becomes more impor-

tant. There is no doubt that from £30 to £100 and over, per annum, in each family, making an enormous sum in the total, might be saved by the invention of machinery to do a considerable part of domestic work. Health also is concerned, as, for instance, in the general use of pneumatic dusters, by which dust, including all sorts of wicked germs, is completely removed, instead of, as at present, being lightly wafted from one resting place to another in the same room. Hitherto, domestic work, large in the aggregate, has been too much divided into small areas of action, to make the application of existing methods of mechanical power suitable, but, with the convenient electrical energy laid on, like water or gas, this objection will be got over. The cry of so many persons being thrown out of employment thereby, may be disregarded. The great engineering works and factories, of the present age superseded the local millwrights of 100 years ago, and the locomotive drove out the teamster, without ultimate harm to any class of worker, so we need not fear the consequences in this particular case, as the substitution, like others of the kind, would be gradual.

Again, we may possibly look for another fruit of the connexion between science and engineering, in the direct utilization for mechanical power of the sun's rays, by some more effective means of concentration than has hitherto been tried. We know, of course, that the sun's heat in past geological ages, is now producing practically all our power, chiefly through the instrumentality of coal, but coal is not inexhaustible, and it has to be mined. Experiments have been made in this direction in South Africa and elsewhere, but though the fuel cost nothing, the expense of the installation has been so large in proportion to the power obtained, that no practical success has been achieved. Here in New South Wales, we would willingly spare a good

deal of our summer heat, to any enterprising syndicate, if they could make use of it. At present, in such countries, the sun's rays are actually a source of waste in some ways, as our perspiring bodies and languid minds, at some periods of the year, sufficiently show. It is very difficult to conceive how this enormous dissipation of energy is to be prevented, but the concentration of potential energy existing in recently discovered substances, may give us hope.

The moon has hitherto been useless to all, except to poets, beyond its occasional light; for its action on tides is as often an impediment as a help to navigation, but could the oft talked of utilization of the rise and fall of the tide, for mechanical power, be made economically available, much of our fuel would be saved.

As far as I know, not much seems to have been done in in the direction of reducing skin friction in ships, though Froude, Sir William White, and others, have made it the subject of their investigations. There is not a word of any attempt to deal with the problem in the exhaustive historical address of Sir William White to the Institution of Civil Engineers last year. Yet the quantity of fuel consumed, in overcoming this resistance, must be enormous, in the great Atlantic liners of the day. And the worst of it is that, as we go on increasing size, we go on, simultaneously, piling up greatly increased skin friction, due to the larger surface and enhanced speed. Might not that important branch of science, curiously called natural history, help us in solving this problem? Observations could be made on the scales of certain fishes, whose speed, in proportion to their propelling power, is far greater than that of the fastest ocean steamer, in order to see how their skin friction has been reduced by natural selection. Long ages of quickness in seizing their prey, and in constant escape from their numerous enemies, must have developed a very efficient

minimum of skin resistance. It is a large subject, with room for great possibilities.

Akin to friction by water, is the resistance of air. Knowledge on this has been much advanced by experiments on the Berlin electric express train trials, on the performance of which I was enabled to give the Society some information in two recent papers. The velocity of the cars, up to 130 miles an hour, is the greatest ever reached by any conveyance, and afforded an unusual opportunity of measuring air resistance, which was fully availed of. Some of the ocean liners, of the present day, have an exposed cross section of over 3,000 square feet, and, when steaming at 23 knots, each pound of air pressure per square foot, on this surface, will absorb over 200 horse power to overcome the resistance offered. The consideration of such facts as these, in connexion with the results obtained on the German train experiments, we may hope will lead to enquiry, as to the best means of coping with this serious impediment to economical speed, on sea and land.

The dispersion of smoke and fog, neither of which however trouble us much in Australia, is a pressing question in some of the older countries, and electricity has been brought into successful requisition for this purpose, in experimental form. It has been estimated that a bad fog in London may cost £5,000 a day for artificial light alone, so that the importance of this question of the future is undoubted. The difficulty lies in the great quantities of electricity to be applied.

As regards the change in the physical qualities of metals used for constructive purposes, especially through what is called fatigue, we are looking for more information from physicists. We owe much to the experiments of Wöhler and Bauschinger, some years ago, but much remains to be discovered. Railway axles, marine shafts, and other

material subjected to constantly varying stresses, bending, torsional, etc., especially require investigation, as to what change of structure is produced by fatigue of this character, and if made, a great scientific and engineering gain would be brought about. Professor Arnold, who has designed a special testing apparatus, gave some interesting particulars on this matter, at the recent meeting of the British Association, when he said the subject was a much more complicated one than was generally supposed.

Great things are expected of single phase electrical working in traction. The difficulties which have hitherto attended this method are being successfully overcome, especially in America, and two lines, Fort Wayne to Springfield, and another in the same State, are being equipped on this system, and favourable results, as regards economy in first cost and working, are confidently expected. The direct current system, hitherto so largely used in such work, has its limitations, in voltage, speed control, etc., and by the alternating current, transforming properties can be brought into use, while the further adoption of the single phase working reduces the first cost, by its requirement of only one conducting wire.

I spoke of the necessity of wonder, for the man of science. One of the most beautiful things in nature is the wondering and wistful look, in the eyes of a child, gazing at the strange things in the glorious world into which it has been brought. By continual questioning, it gradually acquires knowledge of the outward semblances of the earth and sky, the trees and flowers, and their uses to him. To the true scientist, must be given this reverent wonderment, this constant enquiry, in fact, the spirit of a little child, if he is to coax from the great powers of nature, their inmost secrets, and use them, by the aid of his fellow worker the engineer, for the happiness, the well being, and the comfort of his fellow man.

*Roll of Members.*—The nnmber of members on the Roll on the 30th April, 1904 was 347. During the past year 19 members were elected; the deaths numbered 6, resignations 16, and 8 members were struck off the Roll for non-payment of their subscriptions, leaving a total of 336 to date. The following is a list of members who have died during the year:—

Allworth, J. Witter; elected 1885.
Dean, Alexander; elected 1878.
Gipps, F. B.; elected 1876.
King, Hon. Philip Gidley; elected 1874.
Mackenzie, Rev. P. F.; elected 1876.
Trebeck, P. N.; elected 1873.

*Financial Position.*—It is with regret we have to announce that for the first time since receiving a subsidy from the Government of N. S. Wales in 1877, the amount has been reduced by one half, *e.g.*, from £500 to £250. This is due to the very straitened condition of the finances of the State. The sudden withdrawal, without notice, of this amount has necessarily placed the Society in a very difficult position, so much so, that instead of being able to discharge its engagements as heretofore, the Society finds itself in the position of having to commence the new session with outstanding accounts to the amount of £125 2s. 1d. To carry on its work at all will necessitate the exercise of the most rigid economy; to cope with the difficulty will not be easy, and in any case the efficiency of the Society's work will be seriously impaired.

*Library.*—From the Hon. Treasurer's balance sheet it will be seen that during the past year the sum of £54 3s. 3d. was expended on books and periodicals; the binding amounted to £3 19s. 6d. The large and increasing number of periodicals that remain unbound is a matter of urgent need, affecting the convenience of members consulting the library and causing great waste of time to the Librarian.

When funds are available the Council intend to adopt a cheaper style of binding than formerly and will thus minimise the difficulty.

*Exchanges.*—The number of kindred institutions at present on the exchange list to whom copies of the Society's Journal and Proceedings are sent is 433. The following publications were received last year in return:—375 volumes, 1,873 parts, 116 reports, 222 pamphlets, 2 maps, and 1 engraving, total 2,589. This includes a complete set of the Transactions of the American Society of Mechanical Engineers, Vols. I. to XXIV., 1880 to 1903.

*Papers read in 1904.*—During the past year the Society held nine meetings at which 15 papers were read, the average attendance of members was 36 and of visitors 3.

ART. I.—PRESIDENTIAL ADDRESS. By F. B. GUTHRIE, F.I.C., F.C.S., Chemist, Department of Agriculture, N.S.W.; Acting Professor of Chemistry, The University, Sydney.

ART. II.—On the absence of gum and the presence of a new diglucoside in the Kinos of the Eucalypts. By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

ART. III.—On some Natural Grafts between Indigenous Trees. By J. H. MAIDEN, F.L.S., Government Botanist and Director, Botanic Gardens. [*With Plates*]

ART. IV.—Possible Relation between Sunspots and Volcanic and Seismic Phenomena and Climate. By H. I. JENSEN, B.Sc., Junior Demonstrator in Chemistry and Geology, University of Sydney. (Communicated by Prof. T. W. E. DAVID, B.A., F.R.S., etc.)

ART. V.—On Eucalyptus Kinos, their value for Tinctures, and the non-gelatinization of the product of certain species. By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

ART. VI.—Notes on the Theory and Practice of Concrete-Iron Constructions. By F. M. GUMMOW, M.C.E. [*With Plates*]

ART. VII.—Current Papers, No. 8. By H. A. LENEHAN, F.R.A.S., Acting Government Astronomer. [*With Diagrams*]

ART. VIII.—Further Experiments on the Strength and Elasticity of Reinforced Concrete. By W. H. WARREN, Wh. Sc., M. Inst. C.E., M. Am. Soc. C.E., Challis Professor of Engineering.

ART. IX.—The Flood Silt of the Hunter and Hawkesbury Rivers. By Professor T. W. E. DAVID, B.A., F.G.S., F.R.S., and Acting Professor F. B. GUTHRIE, F.I.C., F.C.S.

ART. X.—Ethnological Notes on the Aboriginal Tribes of New South Wales and Victoria. By R. H. MATHEWS, L.S., Associé étranger Soc. d'Anthrop. de Paris; Corres. Memb. Anthrop. Soc., Washington, U.S.A., etc.

ART. XI.—Preliminary Observations on Radio-Activity and the Occurrence of Radium in Australian Minerals. By D. MAWSON, B.E., Junior Demonstrator in Chemistry, and T. H. LABY, Acting-Demonstrator in Chemistry in the University of Sydney.

ART. XII.—Pot Experiments to Determine the Limits of Endurance of different Farm-Crops for certain Injurious Substances. By F. B. GUTHRIE, F.I.C., F.C.S., and R. HELMS.

ART. XIII.—The Occurrence of Isolated Augite Crystals at the top of the Permo-Carboniferous Upper Marine Mudstones at Gerringong, New South Wales. By H. G. FOXALL. (Communicated by Prof. T. W. E. DAVID, B.A., F.G.S., F.R.S.)

ART. XIV.—The Approximate Colorimetric Estimation of Nickel and Cobalt in presence of one another. By R. W. CHALLINOR. (Communicated by Acting Professor J. A. SCHOFIELD, F.I.C., F.C.S., A.R.S.M.)

ART. XV.—Note on a Combined Wash-Bottle and Pipette. By J. W. HOGARTH. (Communicated by Acting Professor J. A. SCHOFIELD, F.I.C., F.C.S., A.R.S.M.)

*Sections.*—The Engineering Section held two Sessions at which three papers were read and discussed :—

ART. XVI.—Tacheometer Surveying with an Ordinary Theodolite. By THOMAS KENNEDY, Assoc. M. Inst. C.E.

ART. XVII.—Water Filtration. By J. M. SMAIL, M. Inst. C.E.

ART. XVIII.—Filtration of Water at the Hunter District Water Works, West Maitland. By J. B. HENSON, Assoc. M. Inst. C.E.

*Lectures.*—A course of five Popular Science Lectures was delivered during the Session 1904, which were well attended :—

June 23—The Distribution of Life in Australasia, by CHARLES HEDLEY, F.L.S.

July 28—The Fabric of the Universe, by Actg. Prof. G. H. KNIBBS, F.R.A.S.

September 22—The Solar System and Southern Sky, by H. A. LENEHAN, F.R.A.S.

October 27—The Steam Engine and its Modern Rivals, by S. H. BARRACLOUGH, B.E., M.M.E., Assoc. M. Inst. C.E.

November 24—The Nervous System in its genesis and development, by J. FROUDE FLASHMAN, M.D.

# ON THE OCCURRENCE OF CALCIUM OXALATE IN THE BARKS OF THE EUCALYPTS.

By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

[With Plate I.]

[*Read before the Royal Society of N. S. Wales, May 3, 1905.*]

THE present inquiry is the outcome of an investigation of four West Australian Eucalyptus barks, to determine their value for tanning purposes. The results, which are published in the April number of the Agricultural Journal of that State, were from the following species:—"Salmon Gum" (*Eucalyptus salmonophloia*), "Gimlet" (*E. salubris*), "Mallet" (*E. occidentalis*), "White Gum" (*E. redunca*).

The results, particularly those from *E. salmonophloia* and from *E. salubris*, were such that it was considered desirable to proceed further, and it was thought that by investigating the barks of the Mallees of New South Wales, information might probably be obtained, not only as regards their tanning value, but which would also help towards elucidating some of the problems connected with these dwarf species of Eucalyptus, and which form such a pronounced feature in many parts of Australia.

The Eucalypts are, generally speaking, forest trees, and often reach large proportions both in height and in circumference, and the prevalence of these dwarf forms, which resemble other species in their morphological characters, is, therefore, somewhat remarkable, and the new facts which have been brought to light during this investigation may assist, perhaps, in their deeper study. The barks of the following Mallees, growing in New South Wales, were

investigated for the purpose of this inquiry:—"Grey Mallee" (*Eucalyptus Morrisi*), "Water Mallee" (*E. oleosa*), "Bull Mallee" (*E. dumosa*), "Green Mallee" (*E. viridis*), "Blue Mallee" (*E. polybractea*), "Mallee" (*E. Behriana*), "Mallee" (*E. gracilis*), "Mallee" (*E. stricta*). The various stages of the bark of the tall smooth barked tree, growing on the Blue Mountains, *Eucalyptus oreades*, were also examined.

When the powdered bark of *E. salmonophloia* was heated with water, white crystals separated in some quantity, of which a considerable amount floated on the top of the water. When boiled for some time the bark débris precipitated, and the crystals could then be removed with a spatula. They were collected in as pure a condition as possible, well washed and dried on a porous slab. Chemical determination showed them to consist of calcium oxalate. Under the microscope they were seen to be well defined monoclinic crystals, consisting principally of stout microscopic prisms. Many of the crystals were twinned, the twinning plane being, apparently, parallel to the basal plane, thus giving the twin a geniculate form. This form of twinning was very apparent with some species, as for instance, *E. polybractea*. The crystals polarised exceedingly well in bright colours. The bark of *E. salubris* gave an abundance of crystals identical in every respect with those obtained from *E. salmonophloia*, and the few crystals from *E. reducna* and from *E. occidentalis* were also identical. From all the barks of the New South Wales Mallees the same characteristic monoclinic crystals were obtained, and in form and appearance they were identical with those from the West Australian barks, with the exceptions that the crystals from *E. gracilis* were generally shorter and stouter, and those from *E. polybractea* were longer; in other respects they were the same. This form

of crystallised calcium oxalate seems, therefore, to be common to the barks of the Eucalypts, but while in some of these the calcium oxalate is present in great abundance, in other species it occurs only in very small amount, as in the bark of *E. Morrisi*, for instance. The mallees which contain the crystals in greatest abundance, seem to be those species which have a very thin smooth bark, or at most a little persistent bark at the base, this is shown with *E. Behriana*, *E. gracilis*, and *E. oleosa*. It does not follow, however, that the thin barks always contain calcium oxalate in abundance, because the barks of *E. stricta* and of *E. polybractea* are both thin and smooth, and contain but a small amount of that salt. In the thicker and more fibrous barks of *E. Morrisi* and *E. viridis* (the thin barks of these species were not determined) crystals were sparsely distributed.

Mr. S. J. Johnston of the Technological Museum has kindly measured crystals of various species, the mean results being as follows:—

| | | | | | | |
|---|---|---|---|---|---|---|
| General type, | length | 0·01746 | mm. | breadth | 0·00776 | mm. |
| *E. gracilis* | ,, | 0·01552 | ,, | ,, | 0·01164 | ,, |
| Ditto, prisms | ,, | 0·0175 | ,, | ,, | 0·00679 | ,, |
| *E. polybractea* | ,, | 0·0291 | ,, | ,, | 0·00582 | ,, |

Mr. R. T. Baker, the Curator (to whom I am indebted for botanical assistance in preparing this paper) had already informed me that on botanical evidence of buds, fruit, leaves, and timber, he could distinguish no difference between *E. salmonophloia* of West Australia and *E. oleosa* of this State. Through the kindness of the authorities of West Australia, the leaves of *E. salmonophloia* were forwarded to the Museum for investigation, and the oil of this species was found to consist of the same constituents as had previously been obtained from *E. oleosa*, and allowing for rather more pinene in the oil of *E. salmonophloia*,

practically no difference could be determined between the oils of these two species, as they both consisted largely of eucalyptol and pinene, with an entire absence of phellandrene. The aldehyde aromadendral was present in both oils. The barks of the two species, however, differed considerably in thickness, but as will be shown later not in chemical constituents,[1] both were identical in this respect and the tannins were alike in both barks. But even with this close botanical similarity and chemical agreement between the constituents of the oils and the barks, it was difficult to understand why a forest tree like that of *E. salmonophloia* should degenerate into the stunted Mallee growth of *E. oleosa.* From the results now obtained it may be possible, perhaps, to offer a feasible suggestion as to the origin of this peculiarity, and there seems no reason to suppose that this alteration into the Mallee form is an isolated case. *E. salmonophloia* and *E. oleosa* being apparently the same tree in different forms of growth, it is probable that the latter is a stage in the slow and permanent degeneration of the larger tree. Although *E. oleosa* is generally seen as a stunted shrub, yet, it often occurs as a persistent tree, and even in New South Wales it is often found having a height of 40 to 50 feet, with a corresponding size of trunk. Mr. R. H. Cambage informs me that in his experience, *E. oleosa* is found in tree form more often than any other species of Mallee. In both *E. viridis* and in *E. Morrisi* trees are often found which have reached to a fair size, but the tendency to early decay appears to be marked in Eucalyptus species which most often take the Mallee form of growth.

It is generally accepted by physiologists that oxalic acid is poisonous to plants as well as to animals, and in Sachs'

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[1] This was also the case with the thin and the thick barks of the "Mallet" of West Australia, *E. occidentalis.*

Text-book of Botany, p. 700, the following appears:—"The importance of calcium must, therefore, be sought partly in its serving as a vehicle for sulphuric and phosphoric acid in the absorption of food material, and partly in its fixing the oxalic acid which is poisonous to the plant, and renders it harmless." Dr. Sorauer says much the same in his Physiology of Plants, Weiss' translation, page 33.

Dr. W. Pfeffer (Physiology of Plants, Ewart's translation page 489) says, "as regards oxalic acid, its affinities, poisonous character, feeble heat of combustion, and the insolubility of its calcium salt are all points to be taken into consideration."

Such generally accepted conclusions must throw doubt upon the possibility of any particular species of Eucalyptus, or in fact of any other genus, to continue to form and dispose of such a large amount of oxalic acid without eventually suffering degeneration both in size and in robustness. In the bark of *Eucalyptus gracilis*, for instance, no less than 16·66% of the entire dried bark consisted of the particular form of calcium oxalate occurring in Eucalyptus barks, and some other species have been found to contain almost as much. If the theory advanced is a feasible one, and obtains support by further evidence, then *E. gracilis* is also the degenerate form of a larger tree. Perhaps this effect is due to the formation of oxalic acid at too rapid a rate to enable the tree to continue to use it without any ill effect, and other conditions be favourable, in the case of certain species, the result becomes apparent in the deposition of an increased amount of calcium oxalate in their barks, which eventually brings about this stunted form of growth.

It may be thought that the shedding of the bark by certain species of Eucalyptus is an effort to throw off this accumulation of calcium oxalate, but the investigation of

the three stages of the bark of one individual tree of *E. oreades* rather discounts this supposition, and suggests the idea that under ordinary conditions the Eucalypts use up the calcium oxalate first formed. Certainly it does not appear to be shed with the bark, and in this respect differs from trees which throw off with their leaves the calcium oxalate formed.

The following results show this clearly:—

| | | |
|---|---|---|
| (*a*) Fresh living bark 2 cm. thick; | calcium oxalate | =1·37% |
| (*b*) Thin ribbon bark 1 mm. thick; | ,, | =0·025% |
| (*c*) Thicker dead bark at base of trunk which was quite brown and 3 to 6 mm. thick; | ,, | nil |

A smooth-bark tree was chosen because most of the Mallees have a smooth bark, or at most a little persistent bark at the base of the tree, or resemble the Boxes, and all have the general characteristics belonging to the larger trees of these classes. The Stringybarks do not appear to take on the Mallee form of growth, and some of the largest trees in Australia are species approaching this class.

That the solution from which the crystallised calcium oxalate was formed must have contained oxalic acid in excess, and thus be more or less poisonous, is indicated by the symmetrically formed crystals, and these crystals, too, belong to a form and have a constitution different from the calcium oxalate usually found in plants. The form peculiar to Eucalyptus barks contains one molecule of water, and has the composition and crystalline form of the mineral *Whewellite*, with which substance it is perhaps identical.

In the banana and other plants calcium oxalate occurs in needle-like crystals or raphides. In the root of the Turkey rhubarb, as well as in other plants, it occurs in crystals having a conglomerate form, and these are also found in some members of the cactus tribe, in *Phytolacca*

*spp.*, in certain algæ and in other small plants. I cannot find, however, that crystallised calcium oxalate has previously been found occurring in quantity in the bark of plants belonging to genera which often occur as immense trees, and in this respect, therefore, the Eucalypts are peculiar. Crystals of carbonate of lime (crystoliths) have been found in the epidermis of some plants, as in a few species of Ficus, but the constituents of this salt are not considered to be poisonous.

The presence of calcium oxalate in quantity in Eucalyptus barks may eventually be found to have some bearing on the formation of the particular tannin present. It has already been determined that in those barks which contain much calcium oxalate the tannin is decidedly superior to that found in species in which the crystals are present only in small amount. Some of these barks should make excellent leather, and the amount of available tannin in some species is considerable. The bark of the "Gimlet," *Eucalyptus salubris*, for example, gave by extraction with hot water 30·5% of total extract, and 18·6% of tannin absorbed by hide powder; these were calculated on the air dried bark. The tannin extracts from this class of Eucalyptus barks do not readily decompose or even darken much when evaporated to dryness at the temperature of boiling water, and the manufacture of excellent tanning extracts from Eucalyptus barks is, therefore, possible.

The amount of calcium oxalate in the bark of *E. salubris* was 16%, and it should be possible to profitably extract this from the bark residue, and thus manufacture oxalic acid very cheaply as a by-product. The oxalic acid should also be obtained fairly pure at the first separation, because the other salts and organic substances precipitated at the same time in the alkaline solution, are readily dissolved by acetic acid. Eucalyptus barks rich in calcium oxalate are easily

ground to a fine powder, so that extraction should be practically complete.

*The calcium oxalate.*

The crystals which were removed from the surface of the water were almost white, and in appearance an impalpable powder. 0·1279 gram of air dried crystals suffered no loss when heated for two hours at 100 – 110° C., but when heated to constant weight at 170 – 180° C., they lost 0·0149 gram, equal to 11·65%; $C_2O_4Ca + H_2O$ contains 12·33% water; on igniting and fully carbonating the residue the calcium carbonate formed was 0·0835 gram. This shows that only one molecule of water was present, because with two molecules only 0·0779 gram could theoretically be obtained, and by the method of collecting, the crystals could not have been quite pure. No magnesia was detected.

The calcium oxalate was determined quantitatively in 4 grams of bark, ground as fine as possible. The barks were boiled with dilute hydrochloric acid, the filtrate made alkaline with ammonia and then acid with acetic acid. The precipitate was determined as calcium carbonate in the usual way. Volumetric determination with permanganate was not satisfactory.

The percentage amounts of calcium oxalate ($C_2O_4Ca + H_2O$) in the anhydrous barks of the several species was as follows. They are calculated from the calcium carbonate found. It is assumed that the whole of the calcium oxalate existed in the crystallised condition, the form and appearance of which can be seen from the micro-photograph attached, for which I am indebted to Mr. J. W. Tremain of the Technical College.

Following are the percentages of calcium oxalate:— *Eucalyptus gracilis* 16·66, *E. Behriana* 16·50, *E. salubris*, 16·00, *E. oleosa*, 10·64, *E. dumosa* 9·80, *E. salmonophloia*

8·34, *E. occidentalis* 6·82, *E. viridis* 5·01, *E. reduncа* 4·46, *E. polybractea* 2·14, *E. stricta* 0·69, *E. Morrisi* 0·08.

The total amount of ash in the barks does not always correspond to the calcium oxalate present; for instance in *E. salubris* the total ash was 18·59%; in *E. gracilis* it was only 13·98%, of which amount 11·41% represents the calcium oxalate.

The general appearance and thickness of the several barks tested were as follows:—

*Eucalyptus gracilis*—a thin, mostly smooth bark, light in colour and not fibrous. Thickness 2 to 3 millimetres.

*Eucalyptus Behriana*—a very thin, smooth bark, light in colour, easily powdered and not fibrous. Average thickness 2 mm.

*Eucalyptus salubris*—a hard, thin, close, brittle bark, brownish to grey externally. Thickness 2 to 5 mm., but rarely more than 3 mm.

*Eucalyptus oleosa*—a somewhat thin and fibrous bark, separating in layers and of a light brown colour. Thickness from 3 to 5 mm.

*Eucalyptus dumosa*—a very thin, smooth bark, of a brownish to grey colour, powders easily. Thickness about 2 mm.

*Eucalyptus salmonophloia*—a thick, smooth bark, salmon to grey externally, somewhat hard and compact, but inclined to be fibrous, powders fairly well. Thickness from 7 mm. to 1 centimetre.

*Eucalyptus occidentalis*—a fairly light coloured bark and having layers of kino in the thicker portions, powders readily. Thickness from 5 mm. to 1 cm. (This bark also occurs much thinner, 2 to 4 mm.)

*Eucalyptus viridis*—a hard, compact bark but interlocked and fibrous; it was taken from a large tree. Externally

it had the general appearance of a "box" bark, and was somewhat dark coloured. Thickness about 1 cm.

*Eucalyptus redunca*—a somewhat thick bark, grey to brown externally with a yellowish fracture. It was quite brittle and fibrous, and not compact. Thickness from 7 mm. to 1 cm.

*Eucalyptus polybractea*—a thin, smooth bark, greenish externally, and in places coated with a brownish tissue-like coating. The thicker portion had a layer of kino. Thickness from 1 to 2 mm.

*Eucalyptus stricta*—a thin, smooth, somewhat fibrous bark, greenish externally. Thickness from 1 to 2 mm.

*Eucalyptus Morrisi*—a thick, fibrous bark, of a dull salmon colour right through, grey and scaly externally. This specimen was from a large tree, the thin bark not being procurable. Thickness from 1·5 cm. to 2 cm.

# ON SO-CALLED GOLD-COATED TEETH IN SHEEP.

By A. LIVERSIDGE, LL.D., F.R.S.,
Professor of Chemistry, University of Sydney.

[*Read before the Royal Society of N. S. Wales, June 7, 1905.*]

PARAGRAPHS have appeared recently in the newspapers stating that gold coated teeth have been found in sheep; and within the last week I received the lower half of a sheep's jaw bone from Mr. Charles G. Alford, the teeth of which are more or less completely incrusted with a yellow metallic looking substance, but more like iron pyrites (marcassite) or brass than gold. The incrustation is brittle and readily comes off in scales when even lightly scratched with the point of a penknife.

The surface of the tooth under the scale was found to be black, but apparentfy not decayed, for when the black coating is scraped off, the surface of the tooth is white; the thickness of the deposit does not apparently exceed the $\frac{1}{32}$ of an inch, or less than 1 mm. Only one tooth was scaled so as to destroy the specimen as little as possible. The scale partly dissolves in dilute acid. The residue consists of filmy organic matter, still possessing a metallic sheen although white in colour instead of yellow. When heated on platinum foil the scale blackens, partly fuses and leaves a white residue soluble in dilute hydrochloric and nitric acids. The residue contains phosphoric acid and apparently consists mainly of calcium phosphate. Under the microscope the scale is seen to be translucent and of a pale brownish colour, and under a half-inch objective it is seen to be made of thin layers, but there is no recognisable organic structure. The metallic lustre is due to the way in which the light is reflected from the surfaces of

the superimposed films. The incrustation on the teeth is apparently a deposit of tartar, and perhaps partly due to superficial decay of the tooth. I think similar coatings on sheeps' teeth have been recorded even in classical times, but I cannot recall a reference. It would be interesting to know whether this deposit on sheeps' teeth is common or not.

I also exhibit a calculus of a similar metallic looking character from a sheep's stomach, deposited in distinct layers round a piece of twig, but of rather a darker bronze tint than the substance on the teeth—this specimen belongs to the Sydney Technological Museum and was kindly lent by the Curator, Mr. R. T. Baker.

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# OBSERVATIONS ON THE ILLUSTRATIONS OF THE BANKS AND SOLANDER PLANTS.

By J. H. MAIDEN, Government Botanist and Director of Botanic Gardens, Sydney.

[*Read before the Royal Society of N. S. Wales, July 5, 1905.*]

THE issue of the third and final volume of the plates contemporaneously prepared by Banks' artists, is an event which assuredly demands the most marked emphasis that we Australians can give it. It is, to us at least, an important historical event. New South Wales was settled 17 years later as a consequence of Cook's voyage, and the

[1] "Illustrations of Australian plants collected in 1770 during Captain Cook's voyage round the world in H.M.S. "Endeavour," by the Right Honorable Sir Joseph Banks, Bart, K.B., P.R.S., and Dr. Daniel Solander, F.R.S., with determinations by James Britten, F.L.S., Senior Assistant, Department of Botany, British Museum, Part iii., 1905." [Part i., 1900; Part ii., 1901].

only place (Botany Bay—called by Cook Stingray Harbour) in modern New South Wales visited by the expedition is a suburb of Sydney. This voyage, therefore, has special interest for us, and it would be regrettable if the appearance of this work were ignored by Australian scientific men.

Through the good offices of Mr. Britten, the Trustees of the British Museum recently presented nearly 600 specimens collected by Banks and Solander to the National Herbarium, Sydney. Many of them are depicted in the work before us.

Mr. Britten's "Introduction" is very interesting. It describes what preparations had been made by Banks for an extensive work to be illustrated by many hundreds of plates and how the issue of it fell through, partly because of Solander's death in 1782 and partly on account of Banks' devotion to his duties as President of the Royal Society. Then follows some description of the various MSS connected with the voyage, including Solander's notes on "Plantæ Novæ Hollandiæ" which are in two volumes (small quarto) and are in the British Museum.

"The Australasian collections are represented by 412 sketches; from these 362 finished drawings were prepared, of which 340 were engraved. From the copper plates of these, the plates illustrating this volume have been lithographed; they represent 328 of the engravings, most of the remainder being unfinished or imperfect representations. Three of the drawings of which no plates exist—*Tribulus Solandri*, *Pleiogynium Solandri*, and *Myrmecodia Beccarii*—being of special interest, were drawn on stone by the late Robert Morgan, and raise the number of plants represented to 331."

That the copper plates of the present work should have remained in the British Museum unpublished for nearly 130 years is a remarkable occurrence, and shows how leisurely the progress of British science can be. While grateful for its belated appearance it seems difficult to believe that this most regrettable delay has been unavoidable.

The excellent illustrations are from contemporary copper-plates engraved from drawings executed by (*a*) Frederick Polydore Nodder, "Botanic painter to Queen Caroline" whose drawings date from 1777 – 1783; 173 drawings are from his pencil. (*b*) John Cleveley's drawings date from 1773 – 1775, and he is represented by 18 in the present work. (*c*) James Miller's drawings date from 1773 – 1775 and there are 47 of them. (*d*) John Frederick Miller's drawings were also executed from 1773 – 1775 and are 61 in number.

Useful notes are given of the engravers D. Mackenzie ("who probably did most of the work") and G. Sibelius. Information is given in regard to Mackenzie's other botanical work. But few of the plates are marked by the engraver's name. The value of the work is enhanced by the fact that it includes representations of many plants which have not been hitherto figured, so far as I am aware.

Mr. Britten gives for each plate a Latin description of each plant depicted (this is the work of Solander) also notes on the localities whence the specimens were obtained, and critical notes. We are informed that descriptions of other plants by Solander are extant, but only those are printed of which there are plates.

The work contains a reduction of Captain Cook's original chart of East Australian coast-line (1770), from originals in the British Museum. This is in a North Sheet and South Sheet. Also a chart of the coast-line of East Australia, as determined by recent surveys to 1890 (inserted for comparison with Cook's coast-line). Also a chart of New Zealand, explored in 1769 and 1770 by Lieutenant J. Cook, Commander of His Majesty's Bark "Endeavour," engraved by J. Bayly. These maps, which render reference to the localities whence Banks and Solander collected exceedingly

easy, are reproductions of those which were issued with Wharton's "Captain Cook's Journal" (1893).

In another place[1] I have given some notes on the synonymy adopted in this work, and herewith continue these observations:

| No. | Name on Plate. | Name in *Flora Australiensis.* |
|---|---|---|
| 251 | *Myristica cimicifera* R.Br. | *M. insipida,* R.Br. |
| | Bentham (and Mueller) unite *M. cimicifera* R.Br. and *M. insipida,* R.Br. under the name *M. cimicifera.* Britten maintains they are distinct species, so the name *M. insipida* should be added to the flora by the side of *M. cimicifera.* | |
| 253 | *Atylus anethifolius,* O. Kuntze. | *Isopogon anethifolius,* Knight |
| 254 | „ *anemonifolius,* O. Kuntze | „ *anemonifolius,* Knight |
| 256 | *Linkia falcata,* O. Kuntze | *Personia falcata,* R.Br. |
| 257 | *Linkia lævis,* Cav. | *Personia lanceolata,* Andr. var. *lævis* |
| | Bentham states that *Linkia lævis,* Cav. is syn. with *P. lanceolata,* var. *lævis.* Britten says it is identical with *P. salicina,* Pers. In my opinion the illustration is clearly *P. salicina,* Pers. and not *P. lanceolata* var. *lævis, unless they are both identical.* See full notes by Britten, and also by Bentham in "Flora Australiensis." | |
| 258 | *Linkia lanceolata,* Britten | *Persoonia lanceolata,* Andr. |
| 261 | *Grevillea pteridifolia,* Knight | *Grevillea chrysodendron,* R.Br. |
| 263 | „ *parallela,* Knight | „ *polystachya,* R.Br. |
| 264 | „ *glauca,* Knight | „ *gibbosa,* R.Br. |
| 268 | *Isostylis ericifolia,* Britten | *Banksia ericifolia,* Linn. f. |
| 269 | „ *integrifolia,* Britten | „ *integrifolia,* Linn. f. |
| 270 | „ *serrata,* Britten | „ *serrata,* Linn. f. |
| 271 | „ *dentata,* Britten | „ *dentala,* Linn. f. |
| 272 | *Banksia cornucopiæ,* O. Kuntze | *Pimelea cornucopiæ,* Vahl. |
| 273 | „ *linifolia,* O. Kuntze | „ *linifolia,* Sm. |
| 277 | *Santalum oblongatum,* R.Br. | *Santalum lanceolatum,* R.Br. |
| 296 | *Omalanthus Leschenaultianus,* A. Juss. | *Carumbium populifolium,* Reinw. |
| 303 | *Hæmodorum corymbosum,* Vahl. | *Hæmodorum coccineum,* R.Br. |
| 309 | *Chlamysporum Banksii,* R.Br. | *Thysanotus tuberosus,* R.Br. var. |
| 312 | *Lomandra longifolia,* Labill. | *Xerotes longifolia,* R.Br. |
| 313 | „ *multiflora,* Britten | „ *multiflora,* R.Br. |
| 314 | „ *filiformis,* Britten | „ *filiformis,* R.Br. |

The part includes figures of *Piper Betle,* Linn. and *Blephocarya involucrigera,* F.v.M., which are not in the *Flora Australiensis.* Figures of recently described plants

[1] Proc. Linn. Soc. N.S.W., 1903, pp. 711–716.

in the present part are *Petalostigma Banksii*, Britten and S. Moore, and *Eugenia Banksii*, Britten and S. Moore.

Some of the propositions of nomenclature gives us a shock. Our familiar *Banksia* is to be suppressed in favour of *Isostylis*. A new *Banksia* is to spring up from the ashes of the almost as familiar *Pimelea*. Our *Persoonias*, in every one's mouth, are to give way to *Linkia*; our *Isopogons* to *Atylus*. *Thysanotus* is to become *Chlamysporum*, while the well-known *Xerotes* is to be *Lomandra*. But the whole of the changes can only be understood by examination of those also proposed in Parts i. and ii.

As I write, the International Botanical Congress (adjourned from Paris, 1900) is meeting at Vienna, and, as the result of its deliberations, it is to be hoped that we shall have the authority of such an influential Congress for a settled nomenclature. When this Congress reports the names proposed in the present work will be passed in review.

Mr. Britten throughout the work, doubtless rightly, attributes to Banks and Solander plants for which in many instances Solander was originally quoted. He says:

"A careful study of the various memoranda and MSS preserved in the Department of Botany makes it clear that Banks, who had come to be regarded as a patron of science rather than as a man of scientific attainments, had much more botanical knowledge than was at one time supposed."

In conclusion, the publication of these fine folio volumes simply whets the appetites of Australians for more. We yearn for the publication of Solander's and Brown's manuscripts, and trust that they will not be kept back from any considerations of nomenclature of species. Such a reason, if advanced, seems to us inadequate in the case of priceless historical documents of the deepest interest to Australians. We would have liked our fathers to have had the privilege of seeing them; shall the privilege be denied to the living

and only be bestowed on a generation yet to be born? With all respect to the eminent specialists forming the scientific staff of the British Museum, we feel sure that these manuscripts must contain observations which can only be fully interpreted and appreciated by Australians.

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## THE REFRACTIVE INDICES, WITH OTHER DATA, OF THE OILS OF 118 SPECIES OF EUCALYPTUS.

By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

[*Read before the Royal Society of N. S. Wales, August 2, 1905.*]

THIS work has been undertaken to determine whether results of value could be obtained by the investigation of the physical constants of eucalyptus oils in this direction. The oils worked upon have—with a few exceptions, added under particular species for comparison—all been distilled at the Technological Museum, from material which was botanically investigated by my colleague Mr. R. T. Baker, F.L.S., before distillation. All the specimens were thus authentic and true to name. The whole of the oil contained in the leaves was distilled over as far as possible, and not the more volatile constituents only, which result can be largely accomplished by regulating the method and time of distillation. The richer commercial oils of *E. polybractea* under No. 22 have been thus obtained.

The general results, concerning most of this material, have already been published by Mr. Baker and myself in our work "Research on the Eucalypts and their Essential Oils," Sydney 1902, so that this paper may be considered

an addendum to that publication. Since that work was published the oils of many other species of Eucalyptus have been obtained, some of which were from West Australia; these are included here also.

In the Proceedings of the Royal Society of Victoria 1894, page 195, Mr. W. Percy Wilkinson records the refractive indices, and other data, of the oils of 18 species of Eucalyptus, several specimens of some of the species being determined. It is very probable, however, that a few were of doubtful origin, as they were obtained from various sources. The oil of *E. globulus*, if true to name, should hardly give so low a refractive index as there recorded with Nos. 36 and 46, which is almost that of eucalyptol itself; nor, should the oil be lævo-rotatory to the extent of 6·2 degrees. Again *E. pauciflora* (=*E. coriacea*) Nos. 28 and 60, contained no phellandrene. The oils of species having the leaf venation characteristic of *E. pauciflora* may reasonably be expected to contain phellandrene, and not to be dextro-rotatory to the extent recorded for No. 28. With undoubted species of Eucalyptus there is a marked agreement in chemical results within certain limits, not only with their oils but with their kinos.

It was thought advisable to determine the refractive indices, and the other necessary data, in the colder months of the year, so as to secure the least variation in temperature. During a large portion of the months of June and July the temperature of the laboratory did not vary more than half a degree from 16° C. either way. The specific gravities were mostly taken at the same time as the refractive indices, but where that was not done the slight correction necessary for 16° C. was made. The solubilities in 70% alcohol were also taken when the room temperature was at 16° C. The alcohol had a specific gravity 0·8722 at 15·5° C. and the method adopted was to transfer 2 cc. of

the oil to a dry test tube, using a narrow pipette, and then to run in 2 cc. of the alcohol from a burette, graduated in tenths, and afterwards by drops until the end was reached, agitating between each addition. The solubilities of the oils in alcohol are given in the previously mentioned work, but only in $\frac{1}{4}$ volumes. The solubility results being of some value, this was not sufficiently delicate, so the more soluble oils were again determined. In no instance, with the crude oils, was solubility reached with an equal volume of 70% alcohol. For the more insoluble oils the previously recorded results were used. Although the specific refractive energy has been calculated for each sample, yet these results do not appear to be sufficiently distinctive, or by themselves of any very great value, but if the solubilities are used in conjunction with the refractive indices, very good results are obtained. The best method appears to be to multiply the refractive index by 10 times the solubility result. As the solubility, diminishes the figures increase considerably. Those Eucalyptus oils richest in eucalyptol have the greatest solubility in 70% alcohol, and have also the least refractive indices, consequently they stand at the top of the list. Only in one instance—that of a highly rectified commercial oil of *E. polybractea*—was a less figure than 15 obtained. This method seems to be a good one by which to determine the quality of a Eucalyptus oil of the eucalyptol class, and would be fatal to sophistication. It might, perhaps, be thought preferable to dispense with the factor, and to use the solubility test simply as an independent check on the refractive index. A standard partly based on these determinations, together with a qualitative test for eucalyptol, might be arranged, and if desired an ester determination might also be made. That the ester content has some influence may be assumed, because in the first 30 of the list of eucalyptol oils, no less than 11 contained esters giving a saponification number between

14 and 27. In many species the ester is most probably geranyl-acetate.

The results have been classified in groups. Those of the first, or eucalyptol oils, are arranged according to the figure obtained by multiplying the refractive index by ten times the solubility; those of the other groups are in alphabetical order. If the perfumery oils like *E. Macarthuri* and *E. citriodora* are omitted, then nearly all those oils which consist principally of eucalyptol and pinene, without phellandrene, (with the exception of *E. Risdoni* and *E. amygdalina*) have a refractive index over 1·47; those not reaching that figure are only just below. The specific gravities of the oils in this group are, in most instances, above 0·91. The solubility in 70% alcohol is a useful means of graduating the members of this group. The yields of oil are, of course, a commercial factor, and these can be obtained from the table of yields published in the work previously mentioned, page 273.

Those oils in which pinene predominates, and in which the sesquiterpene is not pronounced, have also a refractive index over 1·47, but only in one instance did the specific gravity reach 0·91. The comparative insolubility of these oils in 70% alcohol sharply separates them from those of the first group. The phellandrene oils all have a refractive index over 1·48, and in some instances over 1·49 or even higher if the sesquiterpene is in excess. Those oils in which the aldehyde aromadendral is a pronounced constituent all have a refractive index over 1·48, while some of them exceed 1·49. Aromadendral also occurs in small quantity in many oils of the eucalyptol class, but is not present in sufficient amount to exert much influence. The sesquiterpene oils have, as a rule, the highest refractive indices, exceeding 1·5 in several instances. The solubilities in alcohol of the terpene oils appear to have little distinc-

tive importance, with the exception that with those which are somewhat soluble in 80% alcohol, the presence of alcohols, esters, aldehydes, or eucalyptol is indicated.

The oil of *E. Risdoni* is rich in eucalyptol, but contains, when freshly distilled, a small amount of phellandrene. The saponification number for the esters was 27. There seems to be no just reason why the terpene phellandrene should be objected to when occurring in Eucalyptus oils, any more than the terpene pinene, providing the desired amount of eucalyptol is present also. Dr. Hall of Parramatta has shown that the objection to phellandrene as such is not warranted by results. It is, however, unusual to find phellandrene present in oils rich in eucalyptol, as the terpene is usually pinene. The other exception to the general rule is the oil of *E. amygdalina*, (not the oils from its associated species *E. radiata* and *E. dives*). The oil of this species has always appeared to be an abnormal one, and is worthy of special study; it has, however, many distinctive features by wh ch it may easily be determined.

It will be noticed by referring to the original figures that most of the oils have increased a little in specific gravity since they were first distilled, those richest in eucalyptol have, as a rule, increased the most, and the formation of an insoluble deposit in those eucalyptol oils like *E. globulus*, *E. pendula*, *E. oleosa*, etc., seems to be associated somewhat with this slight increase in specific gravity.

The refractive indices were taken with a Fuess refractometer, true for water, and using a sodium light; the results were read to minutes of arc only. The crude oils were used in all instances except where otherwise stated.

The refractive indices of the following constituents occurring in the ordinary types of Eucalyptus oils are :—

| | |
|---|---|
| Eucalyptol (Schimmel) ... ... ... | 1·45961 |
| Pinene (Wallach)... ... ... ... | 1·46553 |

Phellandrene (Wallach) ... ... ... 1·488
Cymene (Brühl) ... ... ... ... 1·48465
Aromadendral ... ... ... ... 1·5141 at 16° C.
Piperitone ... ... ... ... ... 1·4893 at 16° C.
Sesquiterpene (prepared by distillation) 1·5116 at 16° C.

These constituents vary much in amount in the oils of the several species, but it is possible to form groups such as the eucalyptol group, the phellandrene group, etc. The refractive index of the predominant constituent will, of course, influence the result, but there is a marked uniformity between the members of the several groups, agreeing strongly with the indications suggested by the study of the leaf venations.

Eucalyptol-pinene oils; phellandrene usually absent. Refractive index mostly above 1·47 and below 1·48.

| No. | Species. | Refractive index $n_D$ 16° C. | Specific gravity $\frac{16}{15}$° C. | Specific refractive energy $\frac{n_D - 1}{d}$ | Solubility in alcohol (·8722 at 15·5° C.) 1 volume requires | 10 times solubility × refractive index. |
|---|---|---|---|---|---|---|
| 1 | *E. Smithii* ... ... | 1·4706 | ·9238 | ·5094 | 1·05 | 15·44 |
| | Ditto, oil of 'suckers' | 1·4707 | ·9151 | ·5144 | 1·15 | 16·91 |
| | Ditto, com. crude 5·03 | 1·4689 | ·9172 | ·5112 | 1·05 | 15·42 |
| 2 | *E. Bridgesiana* ... | 1·4723 | ·9327 | ·5064 | 1·05 | 15·46 |
| 3 | ,, *Risdoni* ... ... | 1·4733 | ·9373 | ·5049 | 1·05 | 15·47 |
| 4 | ,, *pulverulenta* ... | 1·4686 | ·9280 | ·5049 | 1·1 | 16·15 |
| 5 | ,, *dealbata* ... .. | 1·4705 | ·9268 | ·5077 | 1·1 | 16·17 |
| 6 | ,, *stricta* ... ... | 1·4711 | ·9254 | ·5090 | 1·1 | 16·18 |
| 7 | ,, *polyanthema* ... | 1·4736 | ·9346 | ·5067 | 1·1 | 16·21 |
| 8 | ,, *oleosa** ... ... | 1·4746 | ·9319 | ·5093 | 1·1 | 16·22 |
| 9 | ,, *cordata* ... ... | 1·4695 | ·9265 | ·5067 | 1·15 | 16·89 |
| 10 | ,, *cinerea* ... ... | 1·4706 | 9198 | ·5116 | 1·15 | 16·91 |
| 11 | ,, *populifolia* ... ... | 1·4709 | ·9246 | ·5093 | 1·15 | 16·91 |
| 12 | ,, *Cambagei** ... .. | 1·4720 | ·9243 | ·5106 | 1·15 | 16·92 |
| 13 | ,, *sideroxylon*... .. | 1·4725 | ·9219 | ·5125 | 1·15 | 16·93 |
| 14 | ,, *pendula* ... ... | 1·4732 | ·9337 | ·5068 | 1·15 | 16·94 |
| 15 | ,, *bicolor* ... ... | 1·4734 | ·9266 | ·5109 | 1·15 | 16·94 |
| 16 | ,, *Maideni* ... ... | 1·4736 | ·9253 | ·5117 | 1·15 | 16·94 |
| 17 | ,, *cneorifolia** ... | 1·4747 | ·9194 | ·5163 | 1·15 | 16·96 |
| | Ditto, F. & Co., crude | 1·4774 | ·9375 | ·5092 | 1·1 | 16·25 |
| 18 | *E. maculosa* ... .. | 1·4741 | ·9278 | ·5109 | 1·17 | 17·24 |
| 19 | ,, *Morrisi* ... ... | 1·4693 | ·9191 | ·5106 | 1·2 | 17·63 |
| 20 | ,, *squamosa** ... ... | 1·4692 | ·9202 | ·5099 | 1·2 | 17·63 |
| 21 | ,, *globulus* ... ... | 1·4720 | ·9243 | ·5106 | 1·2 | 17·66 |
| | Do. Platypus bd. 4 yrs | 1·4697 | ·9153 | ·5131 | 1·15 | 16·90 |
| | Do. do. 8 years old | 1·4738 | ·9392 | ·5044 | 1·15 | 16·95 |

## Eucalyptol-pinene oils—*continued.*

| No. | Species. | Refractive index $n_D$ 16° C. | Specific gravity $\frac{16^\circ}{15}$ C. | Specific refractive energy $\frac{n_D - 1}{d}$ | Solubility in alcohol (·8722 at 15·5° C.) 1 volume requires | 10 times solubility × refractive index. |
|---|---|---|---|---|---|---|
| 22 | *E. polybractea** ... | 1·4736 | ·9197 | ·5149 | 1·2 | 17·68 |
| | Do. commer. dist. 6·04 | 1·4686 | ·9286 | ·5046 | 1·0 | 14·68 |
| | Do, do. crude dist. 7·05 | 1·4692 | ·9282 | ·5055 | 1·05 | 15·42 |
| | Do, same oil rectified | 1·4676 | ·9254 | ·5053 | 1·05 | 15·41 |
| 23 | *E. hemilampra* .. | 1·4735 | ·9310 | ·5086 | 1·2 | 17·68 |
| 24 | „ *longifolia* ... ... | 1·4738 | ·9249 | ·5122 | 1·2 | 17·68 |
| 25 | „ *intertexta* ... ... | 1·4748 | ·9323 | ·5092 | 1·2 | 17·69 |
| 26 | „ *Behriana* ... ... | 1·4765 | ·9272 | ·5139 | 1·2 | 17·72 |
| 27 | „ *Stuartiana*... ... | 1·4709 | ·9194 | ·5122 | 1·25 | 18·38 |
| 28 | „ *eugenioides*... ... | 1·4747 | ·9220 | ·5148 | 1·25 | 18·43 |
| 29 | „ *amygdalina* ... | 1·4760 | ·9104 | ·5228 | 1·25 | 18·45 |
| 30 | „ *punctata** ... ... | 1·4774 | ·9297 | ·5135 | 1·25 | 18·46 |
| 31 | „ *Rossii* ... ... | 1·4741 | ·9202 | ·5152 | 1·35 | 19·90 |
| 32 | „ *resinifera* ... ... | 1·4755 | ·9194 | ·5172 | 1·35 | 19·91 |
| 33 | „ *Seeana* ... ... | 1·4706 | ·9146 | ·5145 | 1·37 | 20·14 |
| 34 | „ *camphora* ... .. | 1·4733 | ·9072 | ·5217 | 1·4 | 20·62 |
| 35 | „ *rostrata* var. *borealis* | 1·4747 | ·9251 | ·5131 | 1·4 | 20·64 |
| 36 | „ *viminalis* var. (*a*) ... | 1·4711 | ·9169 | ·5138 | 1·45 | 21·33 |
| 37 | „ *goniocalyx* ... ... | 1·4746 | ·9097 | ·5218 | 1·8 | 26·54 |
| 38 | „ *ovalifolia* v.*lanceolata* | 1·4711 | ·9119 | ·5166 | 2·0 | 29·42 |
| 39 | „ *salmonophloia** ... | 1·4738 | ·9069 | ·5225 | 3·5 | 51·58 |
| 40 | „ *quadrangulata* ... | 1·4692 | ·9075 | ·5170 | 4·0 | 58·76 |
| 41 | „ *Bosistoana* .. ... | 1·4732 | ·9175 | ·5158 | 5·0 | 73·66 |
| 42 | „ *melliodora* ... ... | 1·4706 | ·9041 | ·5205 | 6·0 | 88·23 |
| 43 | „ *redunca* ... ... | 1·4720 | ·9092 | ·5191 | 6·0 | 88·32 |
| 44 | „ *conica* ... ... | 1·4733 | ·9259 | ·5112 | 6·0 | 88·39 |
| 45 | „ *propinqua**... ... | 1·4788 | ·9035 | ·5299 | 8·0 | 118·30 |
| 46 | „ *odorata** (Faulding) | 1·4775 | ·9150 | ·5218 | insoluble 10 volumes 70% alcohol | soluble 1 volume 80% alcohol |
| 47 | „ *occidentalis** ... | 1·4774 | ·9128 | ·5230 | | |
| 48 | „ *dumosa** ... ... | 1·4760 | ·9130 | ·5213 | | |
| 49 | „ *microcorys* ... ... | 1·4747 | ·9059 | ·5240 | | |
| 50 | „ *gracilis** ... ... | 1·4771 | ·9107 | ·5239 | | |
| 51 | „ *paludosa* ... ... | 1·4773 | ·9095 | ·5248 | | |

## Pinene oils; phellandrene absent. Refractive index above 1·47 and below 1·48.

| No. | Species. | Refractive index $n_D$ 16° C. | Specific gravity $\frac{16^\circ}{15}$ C. | Specific refractive energy $\frac{n_D - 1}{d}$ | |
|---|---|---|---|---|---|
| 52 | *E. botryoides* ... ... | 1·4787 | ·8802 | ·5439 | None soluble in less than 7 volumes of 80 per cent. alcohol |
| 53 | „ *calophylla* ... ... | 1·4788 | ·8751 | ·5471 | |
| 54 | „ *dextropinea* ... | 1·4741 | ·8806 | ·5383 | |
| 55 | „ *diversicolor* ... | 1·4747 | ·9134 | ·5197 | |
| 56 | „ *lævopinea* ... ... | 1·4769 | ·8964 | ·5320 | |
| 57 | „ *saligna* ... ... | 1·4760 | ·8940 | ·5324 | |
| 58 | „ *Wilkinsoniana* ... | 1·4774 | ·9016 | ·5295 | |

Pinene-sesquiterpene oils; phellandrene absent. Refractive index above 1·48.

| No. | Species. | Re ractive index $n_D$ 16° C. | Specific gravity $\frac{16^\circ}{15}$ C. | Specific refractive energy $\frac{n_D-1}{d}$ | |
|---|---|---|---|---|---|
| 59 | *E. affinis** ... ... | 1·4921 | ·9270 | ·5301 | None soluble in less than one volume 80 per cent. alcohol, the majority insoluble in 10 volumes 80 per cent. alcohol. |
| 60 | „ *apiculata* ... ... | 1·4934 | ·9123 | ·5408 | |
| 61 | „ *Baeuerleni* ... ... | 1·4841 | ·8890 | ·5445 | |
| 62 | „ *corymbosa** ... ... | 1·4895 | ·8867 | ·5520 | |
| 63 | „ *eximia* ... ... | 1·4889 | ·8999 | ·5433 | |
| 64 | „ *intermedia** ... | 1·4878 | ·8838 | ·5519 | |
| 65 | „ *lactea* ... ... | 1·4898 | ·8794 | ·5570 | |
| 66 | „ *maculata* ... ... | 1·4861 | ·9035 | ·5380 | |
| 67 | „ *nova-anglica* ... | 1·4900 | ·9062 | ·5407 | |
| 68 | „ *paniculata* ... ... | 1·4801 | ·9096 | ·5278 | |
| 69 | „ *patentinervis* ... | 1·4948 | ·8784 | ·5633 | |
| 70 | „ *rubida* ... ... | 1·5011 | ·9089 | ·5513 | |
| 71 | „ *tesselaris* ... .. | 1·4881 | ·8962 | ·5446 | |
| 72 | „ *trachyphloia** ... | 1·4901 | ·8915 | ·5497 | |

Oils in which aromadendral is a pronounced constituent; phellandrene is absent. Refractive index above 1·48.

| | | | | | |
|---|---|---|---|---|---|
| 73 | *E. albens* ... ... | 1·4836 | ·9188 | ·5263 | With the exception of No. 74, all are soluble in either one or two volumes of 80 per cent. alcohol. |
| 74 | „ *hemiphloia* ... ... | 1·4910 | ·9084 | ·5405 | |
| 75 | „ *marginata* ... ... | 1·4946 | ·9112 | ·5428 | |
| 76 | „ *punctata* var *didyma* | 1·4868 | ·9068 | ·5368 | |
| 77 | „ *rostrata* ... ... | 1·4896 | ·9018 | ·5429 | |
| 78 | „ *salubris* ... ... | 1·4841 | ·9013 | ·5358 | |
| 79 | „ *tereticornis* ... ... | 1·4934 | ·9308 | ·5301 | |
| 80 | „ *viridis* ... ... | 1·4828 | ·9027 | ·5348 | |
| 81 | „ *Woollsiana* ... ... | 1·4895 | ·8998 | ·5440 | |

Phellandrene oils containing piperitone. Refractive index above 1·48, several above 1·49.

| | | | | | |
|---|---|---|---|---|---|
| 82 | *E. coriacea* ... ... | 1·4902 | ·9120 | ·5375 | Mostly insoluble in 10 volumes 80 per cent alcohol; none more solubl than with on volume 80 per cent. alcohol. |
| 83 | „ *delegatensis* ... | 1·4881 | ·8645 | ·5646 | |
| 84 | „ *dives* ... ... | 1·4894 | ·8883 | ·5509 | |
| 85 | „ *fraxinoides* .. ... | 1·4908 | ·8762 | ·5601 | |
| 86 | „ *Luehmanniana* ... | 1·4937 | ·8846 | ·5581 | |
| 87 | „ *obliqua** ... ... | 1·4934 | ·8944 | ·5528 | |
| 88 | „ *oreades* ... ... | 1·4945 | ·8935 | ·5534 | |
| 89 | „ *piperita* ... ... | 1·4838 | ·9221 | ·5247 | |
| 90 | „ *radiata* ... ... | 1·4863 | ·8814 | ·5517 | |
| 91 | „ *Sieberiana* ... ... | 1·4886 | ·8947 | ·5461 | |
| 92 | „ *vitrea* ... ... | 1·4828 | ·8967 | ·5384 | |

Phellandrene oils in which the sesquiterpene is a pronounced constituent. Refractive index is above 1·48 and in some instances above 1·5.

| No. | Species. | Refractive index $n_D$ 16° C. | Specific gravity $\frac{16°}{15}$ C. | Specific refractive energy $\frac{n_D-1}{d}$ | |
|---|---|---|---|---|---|
| 93 | *E. acmenoides* .. | 1·5065 | ·9266 | ·5466 | No. 102 is the only oil less soluble than with one volume 80 per cent. alcohol; a large number were insoluble in ten volumes 80 per cent. alcohol. |
| 94 | „ *angophoroides* ... | 1·4881 | ·9207 | ·5301 | |
| 95 | „ *capitellata* ... ... | 1·4828 | ·9176 | ·5261 | |
| 96 | „ *crebra* ... ... | 1·4844 | ·8989 | ·5388 | |
| 97 | „ *Dawsoni* ... ... | 1·5144 | ·9528 | ·5399 | |
| 98 | „ *fastigata* ... ... | 1·4873 | ·8948 | ·5446 | |
| 99 | „ *Fletcheri** ... ... | 1·4881 | ·8882 | ·5495 | |
| 100 | „ *gomphocephala* ... | 1·4815 | ·8752 | ·5501 | |
| 101 | „ *hæmastoma* ... | 1·5013 | ·9196 | ·5451 | |
| 102 | „ *macrorrhyncha* ... | 1·4802 | ·9166 | ·5239 | |
| 103 | „ *melanophloia* ... | 1·4950 | ·8959 | ·5526 | |
| 104 | „ *microtheca* ... ... | 1·4895 | ·8866 | ·5521 | |
| 105 | „ *nigra* .. ... | 1·4871 | ·8838 | ·5511 | |
| 106 | „ *ovalifolia* ... ... | 1·4921 | ·8911 | ·5522 | |
| 107 | „ *Planchoniana* ... | 1·4878 | ·9166 | ·5322 | |
| 108 | „ *pilularis* ... ... | 1·4961 | ·8924 | ·5559 | |
| 109 | „ *robusta* ... ... | 1·4801 | ·8899 | ·5395 | |
| 110 | „ *siderophloia* ... | 1·5000 | ·9081 | ·5506 | |
| 111 | „ *sideroxylon* v. *pallens* | 1·4884 | ·9167 | ·5328 | |
| 112 | „ *stellulata* ... ... | 1·4902 | ·8766 | ·5589 | |
| 113 | „ *viminalis* ... ... | 1·4855 | ·9088 | ·5342 | |
| 114 | „ *virgata* ... ... | 1·5015 | ·9352 | ·5363 | |

Oils not classified; containing geraniol and its acetic acid ester, citral, citronellal, etc.

| No. | Species. | Refractive index $n_D$ 16° C. | Specific gravity $\frac{16°}{15}$ C. | Specific refractive energy $\frac{n_D-1}{d}$ | |
|---|---|---|---|---|---|
| 115 | *E. citriodora* ... ... | 1·4651 | ·8887 | ·5233 | Soluble in 1·5 vols. 70% alco. at 16° C. |
| | Do. Mr. Ingham, Qld. | 1·4678 | ·8829 | ·5298 | |
| 116 | *E. Macarthuri* ... | 1·4793 | ·9271 | ·5172 | Soluble in 1·3 volumes 70% alcohol |
| | Do. cont. 64·73% ester | 1·4763 | ·9252 | ·5148 | |
| | Do. cont. 68·8% ester | 1·4768 | ·9287 | ·5134 | |
| 117 | *E. Staigeriana* ... | 1·4871 | ·8708 | ·5594 | Insoluble in 6 volumes 80% alcohol |
| 118 | „ *aggregata* ... ... | 1·5062 | ·9701 | ·5218 | Insoluble in 10 vols. 80% alcohol |

* Denotes the presence of a small amount of aromadendral in the oil.

# NOTE ON THE DRIFT OF S.S. "PILBARRA."

By H. A. LENEHAN, F.R.A.S.

[With Diagram.]

[*Read before the Royal Society of N. S. Wales September 6, 1905.*]

ON March 3rd, 1905, the engineer reported to the captain that the ship had cast one of the propeller blades. On the 4th, in Lat. 20° 10′ S., Long. 171° 38′ E., the remaining blades were lost. The boat then began to drift in a N.N.W. direction for a couple of days, but on the 7th began to take a course almost due W. Late at night on the 7th as the "Pilbarra" was making direct for the S.E. point of Erromanga, and there seemed every probability of going ashore at any moment, all boats were launched, and the ship deserted to her fate. Next day the captain, when trying to find a landing place, saw his ship some miles to the westward of the island, and again set out to take charge. The drift thereafter was principally to N.W., and the "Pilbarra" was picked up by s.s. "Induna" at 6·25 a.m. on March 17th, and towed to port. I wish to record my thanks to Captain W. R. Fleetwood for the loan of his log, and also to Captain Lindeman, R.N., for placing the same at my disposal.

| Date | Position at Noon. Lat. S. | | Long. E. | | Course. | No. of Miles Drifted. | Condition of Weather. | State of Sea | Wind. |
|---|---|---|---|---|---|---|---|---|---|
| 1905 | ° | ′ | ° | ′ | | | | | |
| March 5 | 19 | 37 | 171 | 18 | ... | 37† | moderating very thick | ... | ... |
| " 6 | 19 | 2 | 171 | 9 | ... | 36† | ditto | ... | ... |
| " 7 | 18 | 42 | 169 | 58 | ... | 68† | ... | high | S.E. str. |
| " 8 | 19 | 6 | 168 | 43 | ... | 75† | mod., fine | ... | ... |
| " 9 | 18 | 54 | 168 | 0 | N. 73 W. | 41* | ... | ... | ... |
| " 10 | 18 | 51 | 167 | 16 | N. 86 W. | 44* | ... | moderate | ... |
| " 11 | 18 | 36 | 166 | 44 | N. 63 W. | 34* | ... | ... | ... |
| " 12 | 18 | 14 | 166 | 26 | N. 38 W. | 28* | ... | ... | ... |
| " 13 | 17 | 56 | 166 | 0 | N. 54 W. | 31* | fine | ... | S.E. mod |
| " 14 | 17 | 40 | 165 | 31 | N. 60 W. | 32* | fine | ... | " light |
| " 15 | 17 | 24 | 165 | 31 | ... | 17† | cloudy | mod. swell | " mod. |
| " 16 | 17 | 22 | 164 | 37 | W | 47† | fine | | " mod. |

* From Ship's Log. † No. of miles computed.

# REINFORCED CONCRETE, Paper III.

The Adhesion of Concrete to the Steel Reinforcement. The Experimental Determination of the Strain Curves and the position of the Neutral Axis in a Reinforced Concrete Beam subjected to Flexure. The form of the Stress Curves derived from the actual Strain Curves. The Design of Reinforced Concrete Structures.

By W. H. Warren, Wh. Sc., M. Inst. C.E., M. Am. Soc. C.E.,
Challis Professor of Engineering, Sydney University.

[*Read before the Royal Society of N. S. Wales, September 6, 1905.*]

The following matters will be dealt with:—

*a.* The adhesion of cement mortar and concrete to steel.

*b.* The experimental determination of the neutral axis in a plain concrete and also in a reinforced concrete beam, and the curves of strain for loads increasing from zero to the load producing fracture, also the determination of the true form of the stress curve from the actual strain curve in a plain and in a reinforced concrete beam.

c. The safe working stresses and the fundamental equations recommended for the design of reinforced concrete structures.

a. *The adhesion of cement mortar and concrete to steel.* The adhesion of cement mortar and concrete to steel was referred to in a former paper,[1] but the results obtained are given in connection with direct tension tests in which failure occurred by the steel bars pulling out of the heads of the specimens. In the following experiments the adhesion

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[1] Further Experiments on the Strength and Elasticity of Reinforced Concrete—Proc. Roy. Soc. N.S. Wales, Sept. 7, 1904.

resistance was determined by pulling out specially prepared bars of Bessemer steel $\frac{5}{8}$ inch diameter, from prisms 12 inches long by 4 × 4 inches in cross-section, consisting of one part of cement to three of builders' sand, and also of one part of cement to two parts of sand and two of stone broken to $\frac{3}{4}$ inch gauge.

The steel bars were prepared with parallel portions 6 inches long, abutting at the centre of the prism, and were pulled out by means of a gradually applied load in the testing machine. The results obtained are recorded in Table I., A, B, and C.

Table I.—ADHESIVE STRENGTH OF CONCRETE TO STEEL.

A. Bars with natural skin on. Hardened in air.

| Number | Composition— Cement | : | Builders' Sand | : | $\frac{3}{4}$ Nepean Shivers | : | Water per cent. | Age in Days | Surface area of bars imbedded sq. in. | Total Load pounds | Adhesion Pounds per sq. in. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I. | 1 | : | 3 | : | – | : | 12 | 45 | 11·78 | 2550 | 216·5 |
| II. | 1 | . | 3 | : | – | : | 12 | 45 | 11·78 | 2600 | 221·0 |
| III. | 1 | : | 2 | : | 2 | : | 10 | 45 | 11·78 | 2175 | 184·5 |
| IV. | 1 | : | 2 | : | 2 | : | 10 | 45 | 11·78 | 2000 | 170·0 |
| B. Bars cleaned with emery paper before embedding. Hardened in air. | | | | | | | | | | | |
| I. | 1 | : | 3 | : | – | : | 12·5 | 45 | 11·78 | 1400 | 118·0 |
| II. | 1 | : | 3 | : | – | : | 12·5 | 45 | 11·78 | 850 | 72·0 |
| III. | 1 | : | 2 | : | 2 | : | 10 | 44 | 11·78 | 1820 | 154·0 |
| IV. | 1 | : | 2 | : | 2 | : | 10 | 44 | 11·78 | 1825 | 155·0 |
| C. Bars cleaned with emery paper before embedding. Hardened in water. | | | | | | | | | | | |
| I. | 1 | : | 3 | . | – | : | 12 | 45 | 11·78 | 1820 | 154·0 |
| II. | 1 | : | 3 | : | – | : | 12 | 45 | 11·78 | 2255 | 191·0 |
| III. | 1 | : | 2 | : | 2 | : | 10 | 45 | 11·78 | 2410 | 204·0 |
| IV. | 1 | : | 2 | : | 2 | : | 10 | 45 | 11·78 | 2250 | 191·0 |

b. *The experimental determination of the neutral axis in a plain and in a reinforced concrete beam, also the curves of strain for loads increasing from zero to the load producing fracture.*

In deriving the equations for determining the position of the neutral axis and the moment of resistance of a transverse section in a reinforced concrete beam, it has been assumed by all authorities up to the present, that a trans-

verse plane section before flexure remains a plane section after flexure. On this assumption the curves of stress on each side of the neutral axis have been derived. The stress strain curve obtained from testing plain concrete prisms in compression under gradually applied loads, in which the abscissæ represent the strains and the ordinates the loads producing them are of approximate parabolic form,[1] and this form is usually assumed for the curve representing the compressive stress from the neutral axis to the extreme fibre, where the maximum ordinate represents the intensity of compressive stress at the extreme fibre.

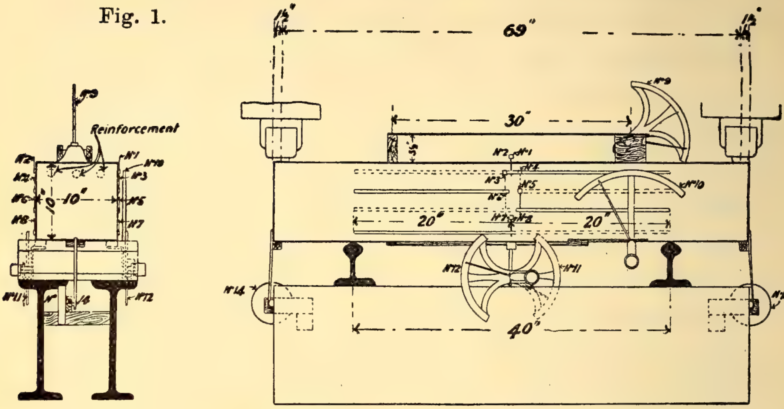
In order to test the accuracy of this assumption, ten beams were made 72 inches long, of square cross section 10 by 10 inches, one beam was of plain concrete, the others were reinforced each with three rods, varying in diameter from $\frac{5}{8}$ of an inch to 1 inch. The beams were supported at points 40 inches apart and loaded at each extremity, so that the bending moments and corresponding stresses between these points of support were nearly constant. Four sets of Martens' mirror extensometers[2] were arranged on each side of the beam to be tested, at equal distances from the centre of the beam, and Martens' sectors were arranged at the top and bottom of the beam in order to determine the strains produced by the loads applied, not only at the extreme fibres, but at four other points in the depth of the beam on each side. Martens' sectors and dials were also attached to the beam in order to determine the end and centre deflections. The loads were applied at the ends of the beam by means of two hydraulic presses, and two rolled steel beams, resting upon the table of a

[1] Further Experiments on the Strength and Elasticity of Reinforced Concrete.—Proc. Roy. Soc. N.S. Wales, Sept. 7, 1904.

[2] Apparatus for ascertaining the minute strains which occur in materials when stressed within the elastic limit, by Prof. Warren. The theory of the Reflecting Extensometer of Prof. Martens, by G. H. Knibbs—Proc. Roy. Soc. N.S. Wales, July and August 1897.

special form of vertical Buckton testing machine, carry the knife edges upon which the concrete beam rests.

Fig. 1.




**Arrangement of Apparatus**

Nos. 1 – 8, Martens' Mirrors. Nos. 9 – 12, Sectors. Nos. 13, 14, Dials.

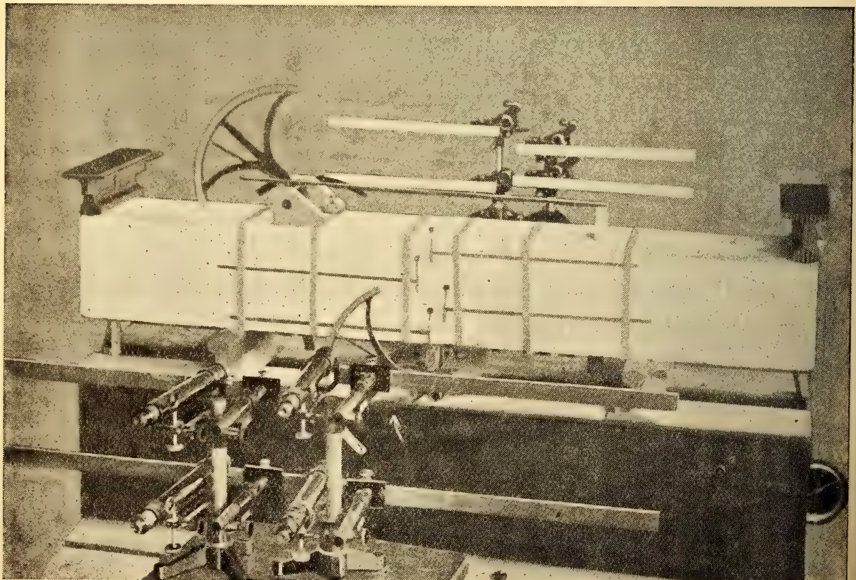
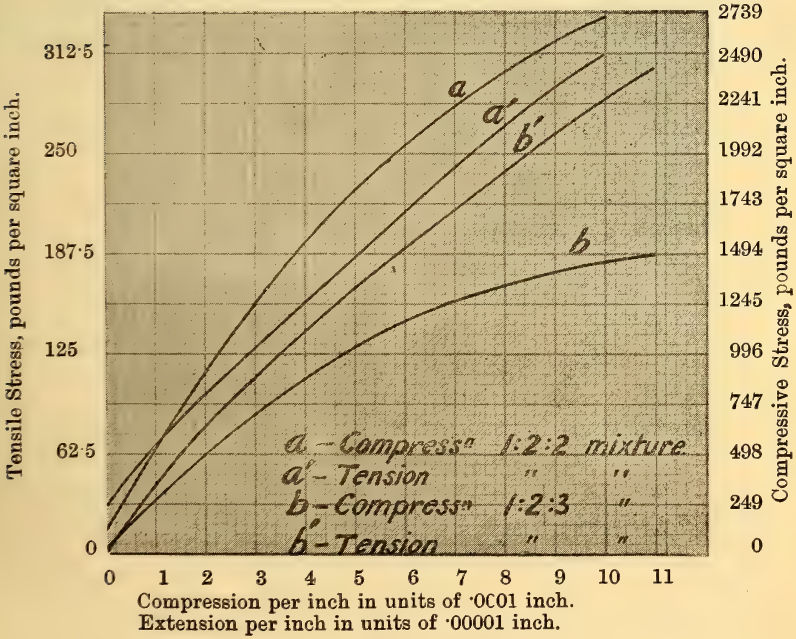


Fig. 2.

The arrangement of the fourteen instruments used in the determination of the various deformations is shown in Fig. 1, but the number denoting each instrument was used for convenience in tabulating the results from which the diagrams Figs. 3 to 6 have been plotted, and has no reference to the numbers on these diagrams. Fig. 2 is a photograph of the beam removed from the testing machine in order to show more clearly the instruments attached to it. In order to derive the stresses from the strains producing them, recorded in the manner above described, experiments were made, on plain concrete prisms, of the same age and composition as the beams under consideration, subjected to compression, and on briquettes of the same material subjected to tension; the results obtained have been plotted in Fig. 3, and from these curves the stress can be determined for each inch in the depth of the beam when the corresponding strain is known.

Fig. 3—Stress-Strain Curves from Tensile Test of Concrete Briquettes and from Compressive Stress of Concrete Prisms (no reinforcement.)



Some of the results obtained in testing the ten beams are recorded in Table II., and in the briquettes and prisms of the concrete used in the beams in Table III.

Table II.—TRANSVERSE TESTS OF REINFORCED CONCRETE BEAMS.

6 ft. by 10 in. by 10 in. Supports 40 in. centres. Loaded at ends.
Reinforced with Bessemer steel bars, Elastic Limit = ——lbs. per sq. in.

| Number | Composition— Cement : Builders' Sand : ¾″ Nepean Shivers | Age in Days | Maximum Deflection measured. Inches | Load at which max. deflec. was measured | Load producing fracture, tons | B. Mt. at fracture = $14{\cdot}5 \times \frac{W}{2}$ inch tons. | Reference to Curve |
|---|---|---|---|---|---|---|---|
| I. | 1 : 2 : 2 | | | Tons | | | |
| | No bars ... ... | 342 | 0·01 | 45 | 45 | 32·6 | Fig. 4 |
| II. | 1 : 2 : 2 | | | | | | |
| | Three ⅝ inch bars ... | 357 | 0·076 | 15 | 16 | 116·0 | |
| III. | 1 : 2 : 3 | | | | | | |
| | Three ¾ inch bars ... | 353 | 0·099 | 19 | 20 | 145·0 | |
| IV. | 1 : 2 : 3 | | | | | | |
| | Three ⅞ inch bars ... | 353 | 0·081 | 18 | 19 | 137·75 | |
| V. | 1 : 2 : 2 | | | | | | |
| | Three ⅞ inch bars ... | 357 | 0·146 | 21 | 22 | 159·5 | |
| VI. | 1 : 2 : 3 | | | | | | |
| | Three 1 inch bars ... | 365 | 0·157 | 22 | 22 | 159·5 | |
| VII. | 1 : 2 : 2 | | | | | | |
| | Three 1 inch bars ... | 369 | 0·109 | 26 | 28 | 203·0 | Fig. 5 |
| VIII. | 1 : 2 : 2 | | | | | | |
| | Three 1 inch bars ... | 314 | 0·074 | 24 | 26 | 188·5 | " |
| IX. | 1 : 2 : 2 | | | | | | |
| | Three 1 inch bars ... | 320 | 0·079 | 26 | 29 | 210·25 | " |
| X. | 1 : 2 : 2 | | | | | | |
| | Three 1 inch bars ... | 319 | 0·069 | 24 | 27 | 195·75 | " |

Table III.—TENSILE TEST OF CONCRETE BRIQUETTES.

| Number | Composition— Cement : Builders' Sand : ¾″ Nepean Shivers | Age in Days | Cross Section inches | Total Load pounds | Load lbs. per square inch | Reference to Curve |
|---|---|---|---|---|---|---|
| I. | 1 : 2 : 2 | 341 | 4 × 4 | 6700 | 418·7 | Fig. 3a′ |
| II. | 1 : 2 : 2 | 339 | 4 × 4 | 6450 | 403·7 | |

Table IV.—COMPRESSION TEST OF CONCRETE PRISMS.

Length equal 12 inches.

| Number | Composition— Cement : Builders' Sand : ¾″ Nepean Shivers | Age in Days | Cross Section inches | Total Load pounds | Load lbs. per square inch | Reference to Curve |
|---|---|---|---|---|---|---|
| I. | 1 : 2 : 2 | 340 | 6 × 6 | 104832 | 2912 | Fig. 3a |
| II. | 1 : 2 : 2 | 337 | 6 × 6 | 94080 | 2613 | |

Fig. 4—Distribution of Strain and equivalent Stress, over the Cross Section of a Plain Concrete Beam as experimentally determined.

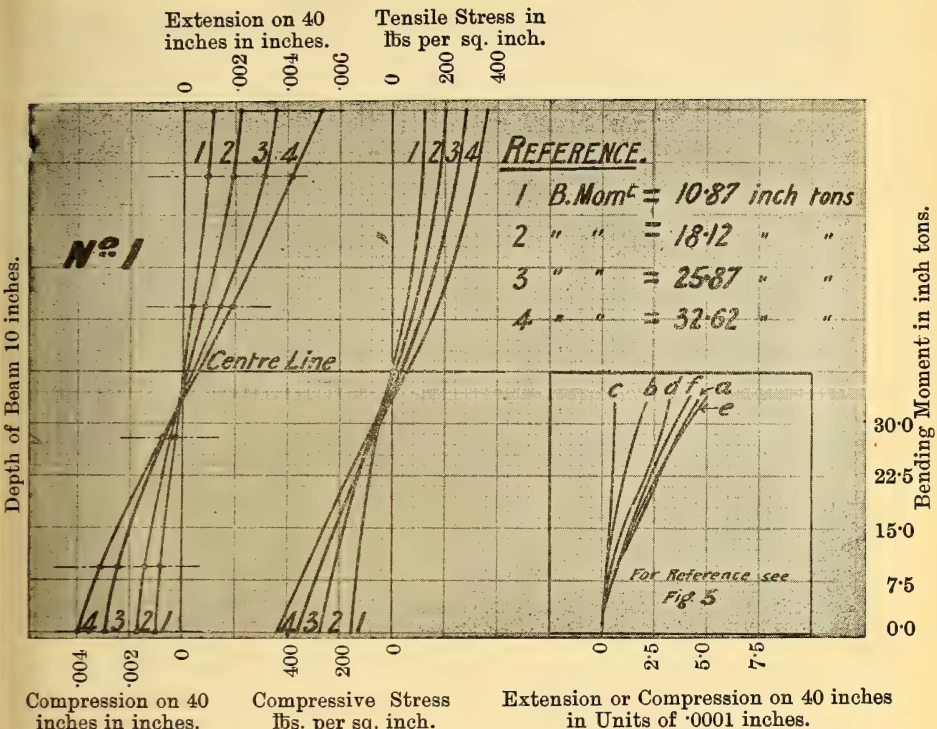
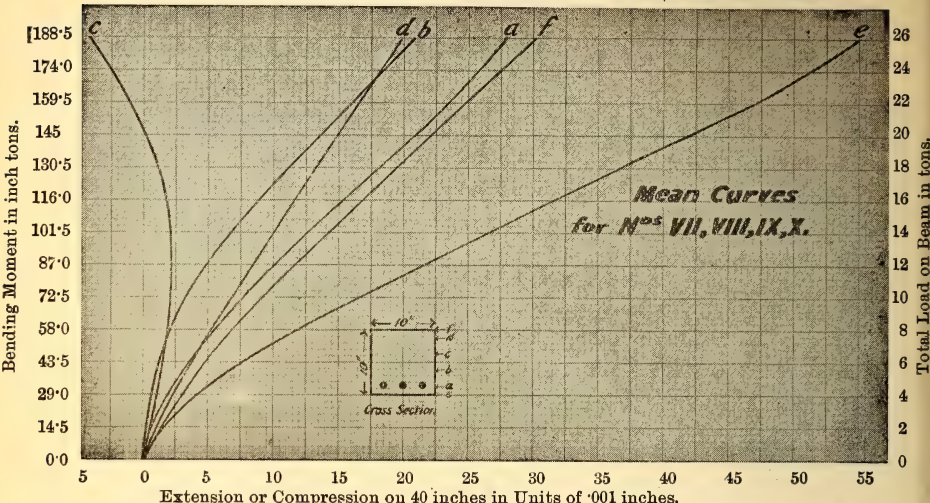



Fig. 4 shows the strain diagram and the stress diagram derived from it, by means of Fig. 3, for a plain concrete beam without reinforcement. The stress diagram showing the distribution of stress in the depth of the beam is shown on the right of the strain diagram.

The curves $c$, $b$, $d$, $f$, $a$, $e$, have been plotted from the deformations obtained by the various instruments attached to the beam at the positions shown in Figs. 1 and 2, the exact distances from the top and bottom and centre of the beam are the same as described in the reference printed under Fig. 5. The results obtained have been used in drawing the strain curves 1, 2, 3, and 4.

Fig. 5—Curves showing the Extension (or Compression) of Fibres of a Reinforced Concrete Beam, measured at several points over the depth of the beam.



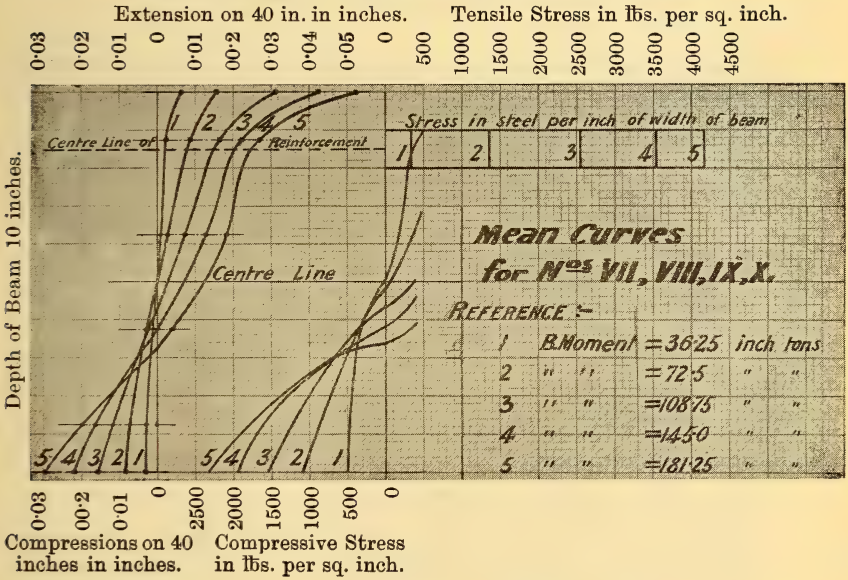

Reference to Curves.

*a*—Extension measured 1¼ inch from tension face of beam
*b*—Extension measured 1¼ inch from centre of beam on tension side
*c*—Compression measured 1¼ inch from centre of beam on compression side
*d*—Compression measured 1¼ inch from compression face of beam
*e*—Extension measured on tension face of beam
*f*—Compression measured on compression face of beam

It will be observed that the neutral axis remains in the centre of the depth up to a bending moment of one-third that necessary to produce fracture, and that it gradually moves towards the compression face of the beam as the bending moment increases, the maximum deviation being 0·8 of an inch. The strain curves 1, 2, 3, and 4, Fig. 4, show how nearly a plane section before flexure remains a plane section after flexure. The stress curves are more curved on the tension than on the compression sides, where they approximate very closely to a straight line. The strains obtained from testing a reinforced concrete beam are recorded in Fig. 5, which gives in each case the mean of tests of four beams of the same material reinforced in a similar manner; the results obtained in the four beams were very consistent and differed very slightly from each other. Fig. 6 shows the actual lengthening or shortening plotted with reference to the depth of the beam in a similar manner to that employed in the strain curves 1, 2, 3, and

4 in the plain concrete beam Fig. 4. In Fig. 6 five strain curves are plotted for five corresponding bending moments, and the stress curves derived from the strain curves by means of Fig. 3 are complete on the compression side of the neutral axis. The curves on the tension side are necessarily incomplete as Fig. 3 does not furnish the data for continuing the curves beyond the points shown, which is the tensile strength of the plain concrete. The stress in the steel reinforcement is determined from the extensions measured, and the coefficient of elasticity of the steel.

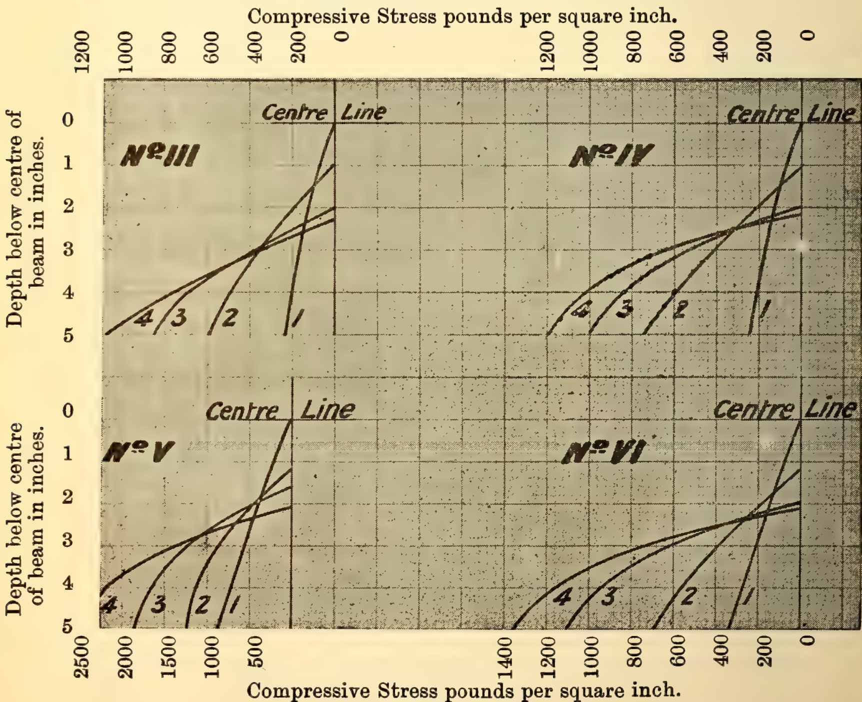
Fig. 6—Distribution of Strain, and equivalent Stress, over the Cross Section of Reinforced Concrete Beams as experimentally determined.




The curves 1, 2, 3, 4 and 5, in the strain diagram on the left of Fig. 6, show that a plane section before flexure is not a plane section after flexure, and that the deviation from the plane is greater as the bending moment increases. Again the neutral axis moves from the centre of the beam towards the compression side as the bending moment

increases. The diagram shows that the neutral axis for a bending moment of 181·25 inch tons is 1·9 inches from the centre, and for the mean bending moment obtained, in testing the four beams 199·4 inch tons, the neutral axis would be nearer to the extreme fibre in compression. The stress curves derived from the strain curves are fairly straight for a bending moment about one-third of that producing fracture, but they are curved for greater bending moments, curves 4 and 5 being approximately parabolic. Fig. 7 shows the results of testing beams III., IV., V. and

Fig. 7—Curves showing the distribution of the Compressive Stresses over the Cross Section of a Reinforced Concrete Beam as obtained by experiment.




REFERENCE.

| | | | |
|---|---|---|---|
| No. III. 1 : 2 : 3 | Concrete, three $\frac{3}{4}$ in. bars. | 1 Bending Moment | = 32·25 in. tons. |
| No. IV. 1 : 2 : 3 | „ „ $\frac{7}{8}$ in. bars. | 2 „ „ | = 72·5 „ |
| No. V. 1 : 2 : 2 | „ „ $\frac{7}{8}$ in. bars. | 3 „ „ | = 108·75 „ |
| No. VI. 1 : 2 : 3 | „ „ 1 in. bars. | 4 „ „ | = 135·0 „ |

Age about 360 days.

VI., but only the stress curves on the compression side of the neutral axis are shown; they are very similar to the stress curves on the compression side of Fig. 6. The neutral axis moves from the centre of the depth of the beam in all four cases, to more than 2 inches towards the extreme fibre in compression, also the curves 1 are practically straight lines, whereas 2, 3, and 4 are approximately parabolic.

The form of the curve of compressive stress in a reinforced concrete beam tested to the breaking point is therefore fairly represented by a parabolic curve, having its origin in the neutral axis, and its maximum ordinate at the extreme fibre in compression, and the equations given in a former paper,[1] express fairly well the conditions of stress in such beams. In applying the foregoing results to the practical design of reinforced concrete beams, we must remember that the curve of stress on the compression side, for working stresses, is more nearly represented by a straight line than a parabola, and that the tensile resistance of the concrete should be neglected for the sake of safety, more especially as it contributes very little to the moment of resistance of the beam.

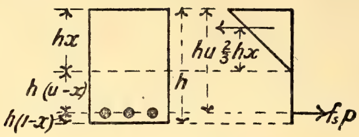
c. *The safe working stresses and the fundamental equations recommended to be used in the design of reinforced concrete.*

| | Pounds per square inch |
|---|---|
| The extreme fibre stresses in concrete compression = | 500 |
| The shearing stress in concrete and the adhesion of the concrete to the steel ... ... ... | 50 |
| The direct compression stress ... ... ... | 350 |
| The tensile stress in the steel reinforcement ... | 16000 |
| The compressive stress ,, ,, ... | 12000 |
| The shearing stress ,, ,, ... | 10000 |

[1] Further Experiments on Reinforced Concrete—Proc. Roy. Soc. N. S. Wales, Sept. 7, 1904.

No tensile resistance must be taken for the concrete.

The ratio $\frac{E_s}{E_c} = 15$




NOTE.—In the bottom line of this diagram for $h\ (1-x)$ read $h\ (1-u)$.

The fundamental equations are[2]:—

$$\frac{cx}{2} = f_s p \ldots(1)$$

$$\frac{c}{f_c} = \frac{E_c}{E_s}\left(\frac{x}{u-x}\right) \ldots(2)$$

$$\frac{M}{bh^2} = f_s p\left(\frac{3\ u-x}{3}\right) \ldots(3)$$

$$x = \sqrt{p^2\ \frac{E^2}{E_c^2} + 2\ pu\ \frac{E_s}{E_c}} - p\frac{E_s}{E_c} \ldots(4)$$

To find the area of the steel reinforcement in a beam 10 inches wide by 20 inches deep to carry 1000 pounds per foot run on a span of 24 feet.

Take $hu = 16$ in order to allow sufficient concrete below the steel bars, so that $u = 0{\cdot}8$.

The bending moment $= \frac{24000 \times 24 \times 12}{8} = 864000$ in. lbs.

$$\therefore \frac{M}{bh^2} = \frac{864000}{4000} = 216 \text{ inch lbs.}$$

$$\frac{M}{bh^2} = 16000\left(\frac{3\ u-x}{3}\right)\ p = 16000\left(\frac{2{\cdot}4\ -\ x}{3}\right)\ p = 216$$

Take $x = 0{\cdot}5$ as a first approximation,

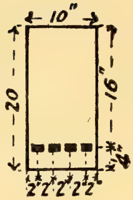
$$\text{then } p\,(2{\cdot}4\ -\ x) = 0{\cdot}0405$$

$$p = \frac{{\cdot}0405}{1{\cdot}9}$$

Let $a$ denote the area of the steel then $p = \frac{a}{bh} = \frac{a}{200} = \frac{{\cdot}0405}{1{\cdot}9}$

$\therefore\ a = 4{\cdot}26$ square inches.

[2] Further Experiments in the Strength and Elasticity of Reinforced Concrete by W. H. Warren—Proc. Roy. Soc. N. S. Wales, Sept. 7, 1904.




We may use 4 bars each $1\frac{1}{8}$ in. × $1\frac{1}{8}$ in. using this new value of $p$ in the equation—

$$x = \sqrt{\frac{p^2 E_s^2}{E_c^2} + 2\,pu\frac{E_s}{E_c}} - p\frac{E_s}{E_c}$$

we find $x = 0{\cdot}486$

$$\text{Hence } \frac{M}{bh^2} = 16000\left(\frac{2{\cdot}4 - 0{\cdot}486}{3}\right)\frac{1}{40}$$

$$= 255{\cdot}2$$

and $M = 1020800$ inch pounds.

This result is nearly 20% greater than the bending moment produced by the load of 1000 pounds per foot run on a span of 24 feet. We may however, reduce the area of the steel reinforcement thus—

$$\frac{M}{bh^2} = 16000\left(\frac{2{\cdot}4 - 0{\cdot}486}{3}\right)p = 216$$

$$\therefore\; p = \frac{a}{200} = 0{\cdot}021$$

$$\therefore\; a = 4{\cdot}22 \text{ square inches.}$$

To find the safe load applied at the centre on a beam 10 × 10 in. when supported at points 10 feet apart: the area of the steel reinforcement is 1·8 square inches. In this case $p = 0{\cdot}018$ and $p^2 = 0{\cdot}000324$. $u = 0{\cdot}85$ $\frac{E_s}{E_c} = 15$

$$x = \sqrt{225 \times 0{\cdot}000324 + 25{\cdot}5 \times 0{\cdot}018} - 0{\cdot}27 = 0{\cdot}45$$

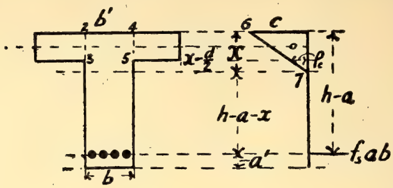
$$\therefore \frac{M}{bh^2} = 16000 \times 0{\cdot}018\left(\frac{2{\cdot}55 - 0{\cdot}46}{3}\right) = 201{\cdot}60$$

$$\therefore\; M = 210600 \text{ inch pounds.}$$

The actual bending moment which produced failure was 604800 inch pounds, so that the factor of safety is—

$$\frac{604800}{201600} = 3$$

MOMENT OF RESISTANCE OF T SECTIONS.




Let $P_c$ = the total compressive strength in the concrete
,, $P_c'$ = the compressive stress in the stem of the T
,, $P_c''$ = the compressive stress in the flange of the ,,
,, $P_s$ = the tensile stress in the steel
,, $S$ = the shearing stress in the concrete in pounds per square inch

$a$ = the sectional area of the steel per inch width of the beam

then—
$$ab\,f_s = P_c = P_s$$
$$ab = \frac{P_c}{f_s} = \frac{P_s}{f_s}$$

Let $S_h$ = the total shear between the rib and flange along their plane of union
,, $S_v$ = the total vertical shear on the two planes 2-3 and 4-5

Assume that $S = \frac{c}{8}$ and also $P_c'' = S_h = S_v$ These assumptions are on the safe side.

It is clear that for equal strength in shear $b$ should be equal to $2d$

If $l$ = the span of the beam in feet

$$S_h = \frac{S}{2} \times b \times \frac{l}{2} \times 12 = 3\,b\,S\,l$$

$$S_v = \frac{S}{2} \times 2d \times \frac{l}{2} \times 12 = 6\,d\,S\,l$$

$$\frac{h - a' - x}{x} = \frac{f_s\,E_c}{c\,E_s}$$

Since the stress-strain curve is a straight line in compression $6-7$, and $\rho_c =$ the intensity of compressive stress on the plane $3-5$ we have

$$\frac{\rho_c}{c} = \frac{x-d}{x} \quad \therefore \quad \rho_c = \frac{c(x-d)}{x}$$

$$\therefore P_c' = \frac{b}{2}(x-d)^2 \frac{c}{x}$$

$$P_c'' = \frac{b'd}{2}(\rho_c + c) = \frac{b'cd}{2x}(2x-d)$$

$$S_h = 3bsl = P_c'' = \frac{b'cd}{2x}(2x-d)$$

$$s = \frac{c}{8}$$

$$\therefore S_h = \frac{3}{8}bcl = \frac{b'cd}{2x}(2x-d)$$

$$\therefore b' = \frac{6blx}{8d(2x-d)}$$

$$\therefore P_c'' = \frac{6blx}{8d(2x-d)} \times \frac{cd(2x-d)}{2x} = \frac{3}{8}blc$$

$$P_c = P_c' + P_c'' = \frac{bc}{2x}(x-d)^2 + \frac{3blc}{8}$$

$$\therefore M = \frac{2P_c'}{3}(x-d) + P_c''\left(x - \frac{d}{2}\right) + P_s(h - a' - x)$$

$$M = \frac{bc}{3x}(x-d)^3 + \frac{b'cd}{4x}(2x-d)^2 + f_s ab(h - a' - x)$$

*Example*—Let $h = 36$ inches
$b' = 36$ inches
$b = 12$ inches
$a' = 3$ inches
$d = 6$ inches
$\frac{E_s}{E_c} = 15$
$c = 500$
$f_s = 16000$
$s = 50$
$ab = 7{\cdot}5$ square inches

$$\frac{h-a'-x}{x}=\frac{f_s}{c}\frac{E_c}{E_s}$$

$$\therefore \frac{33-x}{x}=\frac{16000}{500\times 15} \quad \therefore x=10{\cdot}53$$

$$M=\frac{12\times 500}{31{\cdot}59}(4{\cdot}53)^3+\frac{36\times 500\times 6}{42{\cdot}12}(15{\cdot}06)^2$$

$$+\,16000\times 7{\cdot}5\,(22{\cdot}47)$$

$$=3{,}295{,}594 \text{ inch pounds.}$$

The author wishes to thank Messrs. Gummow and Forrest Steel Concrete Engineers, for their kindness in making the concrete beams referred to in the tests given in this paper. He also wishes to acknowledge the valuable assistance rendered by Mr. A. J. Gibson, Assoc. M. Inst. C.E. and Mr. J. M. C. Corlette, B.E., in connection with the testing and recording the results obtained.

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# On the OCCURRENCE of INCLUSIONS of BASIC PLUTONIC ROCKS in a DYKE NEAR KIAMA.

By C. A. Süssmilch, F.G.S.

[*Read before the Royal Society of N. S. Wales, September 6, 1905.*]

The inclusions (Xenoliths) referred to in this note were obtained by Mr. E. A. Perry and myself from the Bombo Quarries, which are situated at Bombo Point, about two miles north of Kiama. They consist of rounded fragments from 1 to 7 inches in diameter, embedded in a basic dyke rock, which microscopic examination shows to be a monchiquite. The permo-carboniferous lava flows, in which the Bombo quarries occur have recently been described by Messrs. J. B. Jaquet, G. W. Card,[1] and L. F. Harper, as an orthoclase basalt, and in the same paper they also map and describe a number of dykes of olivine basalt and monchiquite intruding these flows at Bombo Point. The specimens containing the plutonic inclusions were found near the north-east of the quarry, as loose fragments on the quarry floor. A careful search failed to obtain them *in situ*. A microscopic examination of the monchiquite shows it to be identical with that described from the dyke No. 36 on the map accompanying the above mentioned paper, and if this dyke continues in the direction indicated, it would cross the quarry just about at the place where our specimens were obtained. There is little doubt therefore that these specimens formed part of a continuation of this dyke.

[1] Geology of the Kiama-Jamberoo Districts.—Records of the Geological Survey of N.S. Wales, Vol. VIII., part i., by John B. Jaquet, A.R.S.M., F.G.S., George W. Card, A.R.S.M., F.G.S., and L. F. Harper, F.G.S.

## Petrographical Description of the Inclusions.

The following plutonic rocks were found to occur (1) hypersthene gabbro, (2) augite peridotite, (3) enstatite peridotite (saxonite), (4) pyroxenite. These all occur in the form of more or less rounded fragments and boulders embedded in the monchiquite, the roundness being probably the result of corrosion by the molten dyke rock.

### I. Hypersthene Gabbro.

a. *Megascopic Characters.*

Colour, black and white, mottled
Fracture, rough
Crystallinity, phanerocrystalline
Granularity, { relative, even; absolute, medium, grainsize about 2 mm.
Minerals visible, 1. plagioclase, 2. pyroxene.

b. *Microscopic Characters.*

Texture { 1. Crystallinity, holocrystalline; 2. Fabric, allotriomorphic granular; 3. Grainsize, 1·7 mm.

Minerals present (in order of decreasing abundance)

i. Pyroxene { *a.* augite; *b.* hypersthene
ii. Labradorite (medium variety)
iii. Magnetite

The combined pyroxenes predominate over the felspar. The relative proportions of the former vary, in some slides the hypersthene predominates over the augite, in others the contrary is the case. The rock is remarkably fresh.

### II. Augite Peridotite.

a. *Megascopic Characters.*

Colour, brownish-black
Fracture, rough
Crystallinity, phanerocrystalline

Granularity, { relative, uneven
absolute, medium to coarse, individual crystals up to 10 mm. }

Minerals visible, i. olivine, ii. pyroxene, iii. biotite

b. *Microscopic Characters.*

Texture { Crystallinity, holocrystalline
Fabric, pœcilitic for the most part
Grainsize, very uneven, averages 2·3 mm. }

Minerals present (in order of decreasing abundance)
i. olivine, ii. augite, iii. enstatite, iv. biotite, v. magnetite.

The olivine occurs as more or less rounded grains from 1 to 2 mm. in diameter enclosed in the larger augite crystals; more rarely it shows crystal outlines. The characteristic alteration into serpentine is present, but the mineral is, on the whole, remarkably fresh. The augite occurs as large allotriomorphic crystal up to 10 mm. in diameter, enclosing the olivine crystals giving the characteristic pœcilitic structure. Enstatite is only sparingly present, as also is the biotite, although in one fragment the latter is fairly abundant. The order of crystallization was 1. magnetite, 2. biotite, 3. olivine, 4. pyroxene.

III. ENSTATITE PERIDOTITE.

a. *Megascopic Characters.*

Colour, yellow to yellowish-green

Fracture, rough

Crystallinity, phanerocrystalline

Granularity, { relative, even
absolute, medium }

Minerals visible, olivine, pyroxene, picotite.

b. *Microscopic Characters.*

Texture { Crystallinity, holocrystalline
Fabric, allotriomorphic granular
Grainsize, average about 1·8 mm. }

Minerals present (in order of decreasing abundance)
1. olivine, 2. enstatite, 3, augite, 4. picotite.

The olivine preponderates and in some examples the rock consists almost entirely of this mineral. The pœcilitic structure so characteristic of the previous rock is absent. Augite is only sparingly present. The enstatite occurs in allotriomorphic crystals ranging up to nearly 4 mm. in diameter. The picotite occurs as small rounded granules enclosed in the other minerals, but is not abundant.

IV. PYROXENITE. Consists practically of augite only with an occasional small crystal of olivine; is phanerocrystalline and the fabric is allotriomorphic granular.

Besides these rocks several large isolated crystals of augite were found, all of which have been corroded by the enclosing rock. The largest example measured 3 inch by 2 inch by 1 inch.

PETROGRAPHICAL DESCRIPTION OF THE MONCHIQUITE.

a. *Characters as seen in the hand specimen.*

Colour, blue-black
Fracture, even
Cystallinity, aphanitic
Granularity, relative, even, not porphyritic
Minerals visible, none recognisable.

b. *Microscopic Examination.*

Texture:
- Crystalline, hypocrystalline
- Fabric, the olivine and augite are automorphic the latter more or less lath-shaped and together with the other mineral set in a more or less isotropic base.
- Grainsize, average about 0·2 mm.

Minerals present (in order of decreasing abundance) 1. augite (titaniferous), 2. olivine, 3. magnetite, 4. felspar, 5. biotite, 6. apatite and an isotropic base.

Mr. G. W. Card gives the following description of the monchiquite from Dyke No. 36:—" Under the microscope

the typical isotropic base of the monchiquites is well shown. The olivine phenocrysts are more or less automorphic and may be partly or entirely serpentinised. The augite is automorphic and slightly pleochroic, some of the smaller phenocrystalline individuals may form glomero-porphyritic aggregates. Magnetite is abundant in small crystals. Felspar occurs in the groundmass to some extent. Altered leucite is probably present. The base is abundant." A comparison of these two descriptions will show that the two rocks are essentially the same.

## Similar Occurrences.

In 1893 the presence of a "Chromite-bearing Rock in the Basalt at the Pennant Hills Quarry, near Parramatta was pointed out by Prof. T. W. E. David and Messrs. W. F. Smeath and J. A. Wall, in a paper to this Society. Since that time numerous fragments of gabbro, peridotite and allied rocks have been obtained from this locality; the basalt in which they are enclosed occurring in the form of a volcanic neck. In 1902 Mr. G. W. Card[1] in the Records of the Geological Survey of N.S.W., wrote as follows :—"It may be noted that enclosures of a basic character are by no means uncommon in the basalts traversing or overlying the Hawkesbury formation. Thus boulders of gabbro occur in this way at the Pennant Hills Quarry, Dundas, near Sydney, and gabbro also occurs in olivine basalt from Glen Alice, Capertee. Colourless pyroxene, resembling that of eclogite has been detected in basalts from Mount Wilson, Rooty Hill, Thirlmere and Long Bay near Sydney. In the nepheline basalt from Burragorang a pyroxene containing picotite has been noted. At Bulli a dyke contains large lumps of an aggregate of hornblende, olivine and picotite.

[1] An Eclogite-bearing Breccia from the Bingera Diamond Field by George W. Card, A.R.S.M., F.G.S., Records of the Geological Survey of New South Wales, Vol. VII., part ii.

It would thus appear that masses of holocrystalline basic rocks must exist at no great depth in this portion of Australia." Mr. Card informs me that in examining many of the other dyke rocks he has noticed many inclusions of foreign crystals (Xenocrysts) similar to those already quoted.

The occurrence of the fragments of gabbro and peridotite in the dyke at Kiama points to a similar conclusion to that arrived at by Mr. Card, and considerably extends the area beneath which basic and ultrabasic plutonic rocks probably exist in eastern New South Wales.

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# NOTE ON SOME SIMPLE MODELS FOR USE IN THE TEACHING OF ELEMENTARY CRYSTALLOGRAPHY.

By W. G. Woolnough, D.Sc., F.G.S.

(Communicated by Prof. T. W. E. David, B.A., F.R.S.)

[*Read before the Royal Society of N. S. Wales, October 4, 1905.*]

In the course of nearly ten years' experience in the teaching of elementary crystallography, I have found it very difficult to make the average student appreciate the connection between the number of faces in a crystallographic "form" and the elements of symmetry characteristic of the group to which the crystal belongs. I have, therefore, prepared several very simple models which, I find, make the understanding of this very important point perfectly easy to everyone.

A plane of symmetry divides a crystal into two portions which are to one another as an object and its reflection in

a mirror. The use of a mirror therefore explains the effect of a plane of symmetry exactly, and the combination of several mirrors reproduces the effect of the highest orders of symmetry.

I have constructed models representing the symmetry of the normal group of each of the six systems of crystals. Those for the cubic, tetragonal, hexagonal and rhombic systems consist of three mirrors each; that for the monoclinic system of a single mirror and a rotating axis; that for the triclinic system simply of a cork.

The mirrors should be of the thinnest gauge of glass obtainable, and must be cut very accurately to shape, and very carefully assembled, or else the multiple reflections give a distorted figure. I found it possible to get the glass cut much more accurately if ordered in rectangular shapes, than if triangles of given angles are specified. I made six inches my unit of length and then the following glasses were needed:—

5 squares, 6 inches × 6 inches (3 for rhombic, one each for tetragonal and hexagonal).

1 square, 6 inches × 6 inches, cut across diagonally (one part for cubic, one for tetragonal).

2 rectangles, 6 inches × 8·48 inches—$6\sqrt{2}$ inches—(one for tetragonal, one for monoclinic).

1 rectangle, 6 inches × 8·48 inches, cut across diagonally, (both parts for cubic).

1 rectangle, 6 inches × 6·93 inches—$4\sqrt{3}$—(for hexagonal).

1 rectangle, 6 inches × 3·46 inches—$2\sqrt{3}$—(one part for hexagonal, one part wasted).

The pieces are fixed together by means of strips of paper gummed across the edges of adjacent pieces at the back. The figures (fig. 1) are of the nature of "nets" to indicate the construction of the models for the first four systems.

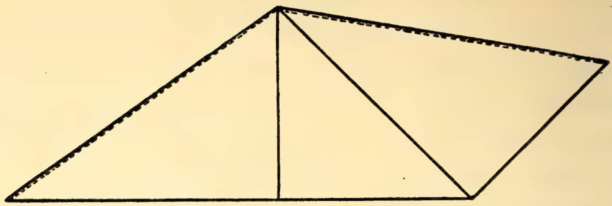

Fig. 1. Cubic

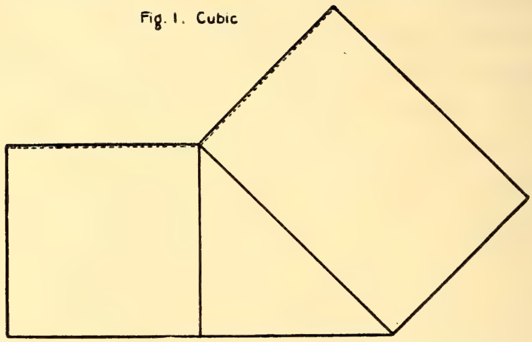

Fig. 2. Tetragonal.

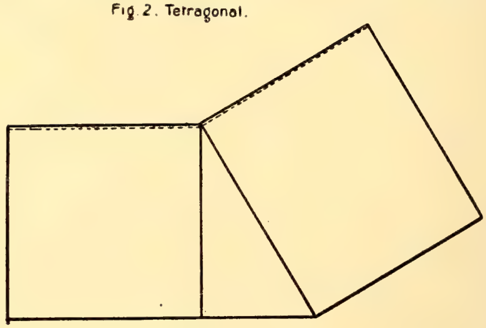

Fig. 3. Hexagonal.

Figs. 1, 2, 3, 4—Nets to show construction of the models for cubic, tetragonal, hexagonal, and rhombic systems. The edges indicated by dotted lines are to be joined.

A crystal face of the most general form is represented by a triangle of cardboard of suitable size and shape. This is placed in the solid angle between the three mirrors when the multiple reflections will reproduce all the faces of the

form, forty-eight for the cubic, twenty-four for the hexagonal, sixteen for the tetragonal, and eight for the rhombic. For the rhombic model the card may take the form of any acute angled triangle. For the tetragonal model the acute angled triangle must have one angle less than 45 degrees, for the hexagonal less than 30 degrees.

As it is rather difficult to cut a card which will fit into the cubic model, I have calculated the shapes required for some of the principal forms. It will be noticed that in figure 1 the mirrors are lettered H, V and S, respectively. The model should be placed with H horizontal and V vertical. The following are suitable triangles, the edges which are to come into contact with the mirrors being indicated by means of similar letters:

| | | | |
|---|---|---|---|
| Octahedron | (111) | sides in proportion of | $H=\sqrt{3}$ $V=1$ $S=2$ |
| Cube | (100) | ,, ,, | $H=1$ $V=1$ $S=\sqrt{2}$ |
| Dodecahedron | (110) | ,, ,, | $H=\sqrt{2}$ $V=1$ $S=\sqrt{3}$ |
| Hexoctahedron | (123) | ,, ,, | $H=\cdot745$ $V=\cdot570$ $S=\cdot915$ |

Cards of the first three shapes show very instructively the fact that the simpler forms of the system may be regarded as limiting cases of the general form.

The models are instructive in other ways. For instance, in the case of the cubic model, if a rod be held in the position of a centronormal to any particular crystal face, the multiple reflections show the positions of all the centronormals to all the faces of the form. It will be found that there are seven distinct ways in which the rod may be held corresponding with the seven types of form possible in the group.

Thus, if the rod be laid in the dihedral angle of H and S, the positions of the six centronormals of the cube, coinciding with the three quaternary axes of symmetry, appear. If the rod is laid somewhere on the face H, the twenty-four centronormals of a tetrahexahedron appear. If the

rod is held so as not to touch any of the mirror faces, but to project between them from the trihedral angle, the forty-eight centronormals of a hexoctahedron appear, and so on. Obviously the edges $\mathrm{H}{\frown}\mathrm{S}$, $\mathrm{S}{\frown}\mathrm{V}$, $\mathrm{V}{\frown}\mathrm{H}$ correspond respectively with the positions of the quaternary, ternary and binary axes of symmetry of the group.

A different procedure is adopted in the case of the monoclinic model. Here we have a plane of symmetry at right angles to it (and therefore also a centre of symmetry) with a dyad axis of symmetry. One of the large rectangles has a hole bored in its centre. Through this is passed an axis, working freely in the hole, and kept normal to the mirror by means of a cork on each side of the glass. These corks, by their friction with the glass, keep the axis in any position it may be placed. Two exactly similar pieces of card of convenient size and shape are cut to represent faces. One of these is fixed by one of its vertices to the outer end of the axis, its opposite side supported just clear of the mirror by means of two long pins fixed in the cork to the card. With this card in any convenient position the other card is fixed to the mirror by means of a paper hinge in such a way that it exactly coincides with the first one. A narrow "bridle" of paper is then fixed to the free surface of this second card and to the mirror to keep t in position when the other card is removed. With the cards in coincidence the reflection in the mirror shows how the plane of symmetry necessitates the development of another face (fig. 1). Now lift the hinged card a little, rotate the axis through 180 degrees and allow the hinged card to drop into its former position (supported by the bridle), and the four faces of the most general form of the normal group of the monoclinic system at once appears in a way which appeals very forcibly to the imagination of the pupil (fig. 6).

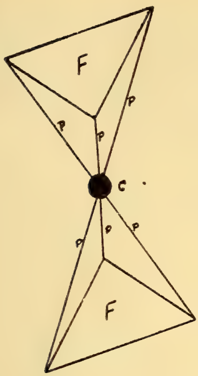


Fig. 7. Triclinic

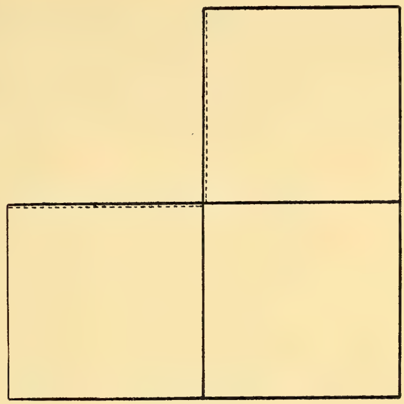

Fig. 4. Rhombic

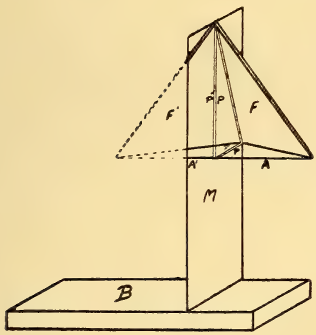


Fig. 5.

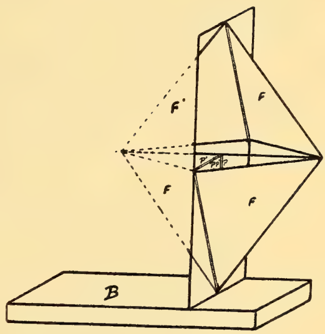


Fig 6

Fig. 5—Model for monoclinic system showing effect of a single plane of symmetry.

Fig. 6—The same with the rotating axis turned through 180°, showing the effect of a single plane of symmetry and an axis of binary symmetry at right angles to it. *M*—mirror representing plane of symmetry; *A*—rotating axis; *F*—card to represent face of a crystal; *P*—pins carrying *F*; *A'*, *F'*, *P'*—reflections of *A*, *F*, and *P* in *M*.

Fig. 7—Model for triclinic system showing effect of a centre of symmetry without any other element of symmetry. *C*—cork carrying pins and representing centre of symmetry; *F*—card to represent face of a crystal; *P*—pins carrying *F*.

The triclinic model consists simply of a spherical cork, on opposite sides of which, supported by large pins are two triangular cards in the positions necessitated by the centre of symmetry, which is the sole element of symmetry of the group.

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# Provisional DETERMINATION of ASTRONOMICAL REFRACTION, from Observations made with the Meridian Circle Instrument of the Sydney Observatory.

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[*Read before the Royal Society of N. S. Wales, November 1, 1905.*]

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## 1. Introduction.

For some years past the meridian circle instrument of the Sydney Observatory has been in constant use for observing the transits and zenith distances of certain stars. The working lists have been prepared for the purpose of providing data for deducing the constants of reduction for the photographic plates, taken with the astrographic telescope. Eventually the positions of the stars, observed

with the meridian circle, will be recorded in a catalogue that may be used for other purposes. The value of such a catalogue will depend largely on the final methods adopted in discussing the data, and publishing the investigation for the benefit of future research work in other directions.

No modern star catalogue is complete without appending an investigation into the systematic corrections required to reduce the observations to some acknowledged standard or system, such as that of Newcomb, Boss, or Auwers. An investigation of this nature is essential to define the value of the whole work. In this connection Dr. Auwers has perhaps done more than any other astronomer; through his labours it is now possible to reduce the data of almost every published star catalogue to a uniform system.

The present paper, together with another on the "Latitude of the Sydney Observatory," is preliminary to the question of preparing a star catalogue to be issued from the Sydney Observatory.

My best thanks are due to Mr. Lenehan, F.R.A.S., the Acting Government Astronomer, who kindly granted permission to use the meridian circle to obtain the necessary observations. I have also to thank Mr. Raymond, F.R.A.S., together with Messrs. Olden and Cranney, officers of the Observatory staff, for assistance in the observations and reductions.

## 2. Instrument.

The instrument, with which the observations were taken, is the meridian circle of the Sydney Observatory. This instrument was constructed by Messrs. Troughton and Simms of London, and erected in its present position, during the year 1875, by the then Government Astronomer, Mr. H. C. Russell, C.M.G., F.R.S.[1] A description of the instru-

[1] Retired from office 1905, February 28.

ment[2] is given in "Astronomical Results, Sydney Observatory 1879-80-81.

The instrument does not conform to modern ideas of construction, nevertheless it is a remarkably good one, and built on a secure foundation, the instrumental corrections remain normal during long intervals of time, in this connection it has given no trouble.

### 3. The Observing Room.

The observing room for the meridian circle is situated in the central part of the main building. The observing slit measures only fifteen inches in width, and is provided with shutters on the roof of the building, a door and sliding windows are used for closing the opening in the northern and southern walls respectively. The general arrangement, originally very defective, is now much better, but the room is too small and badly situated for the fundamental instrument of the Observatory.

### 4. Meteorology.

The standard thermometer is exposed in a louvred shed 12 feet by 12 feet, with walls about 12 feet 6 inches high; the cover is in the form of a pyramid, the base of which rests on the four walls, the apex being 13 feet from the floor level. This shed is some 50 feet due south of the meridian circle. The barometer is in the main building, suspended on brackets attached to the southern face of the equatorial instrument pier on the ground floor. The readings of the barometer and attached thermometer were obtained from the records of the meteorological branch of the Observatory, as well as that of the standard thermometer. The variations of these were obtained from the self recording instruments. A thermometer was also read

[2] A reproduction of a photograph of this instrument is given in the volume noted, over the title " Sydney Transit Instrument and Reverser."

at stated times during the evening's work, the indications showing that the observing room was generally between three and five degrees higher in temperature than that denoted by the external thermometer.

### 5. Method of Determining the Refractions.

#### Notation.

$z'$ = Apparent zenith distance.
$\delta'$ = Distance, in arc, from the equator, measured on a great circle at right angles thereto, positive towards the north.
$\phi$ = Latitude
$r$ = Refraction observed
$r'$ = Refraction calculated from tables.
The suffixes $n$ and $s$ refer to north and south.

If we put

$$\delta'_n = \phi + (z'_n + r_n) \text{.........} 1$$

$$\delta'_s = \phi - (z'_s + r_s) \text{.........} 2$$

and subtract equation (2) from (1) then

$$\delta'_n - \delta'_s = z'_n + z'_s + r_n + r_s$$

Put $$X = \delta'_n - \delta'_s$$

$$Y = z'_n + z'_s$$

then $$X - Y = r_n + r_s$$

$$2\, r_n - r_n + r_s = X - Y$$

or $$r_n = \tfrac{1}{2}(X - Y) + \tfrac{1}{2}(r'_n - r'_s) \text{.........} 3$$

In a similar manner

$$r_n = \tfrac{1}{2}(X - Y) + \tfrac{1}{2}(r'_s - r'_n) \text{.........} 4$$

It will be noted from the above deductions, that if the northern and southern zenith distances were the same, and the meteorological data similar, then the refraction for each would be the same, that is, we should have

$$r_n = r_s$$

in which case $$2\, r = X - Y$$

These ideal conditions could not be expected. In the method here adopted, it is assumed that the error of the quantity $\pm r'_n \mp r'_s$, deduced from the tables, can be neglected, this assumption is very near the truth, if the observed zenith distances of a pair of stars do not differ to any great extent. In this respect much care was taken in the selection of the stars to be observed, so that the zenith distances of a pair approached equality.

In the Talcott method for the determination of latitude the idea is to eliminate the refraction. To obtain the refractions by the method here shown, the idea is to eliminate the latitude from the equations.

To obtain values of $r$ from equations (3) and (4) it is necessary to know the correct declinations of the observed stars, together with the sum of the zenith distances of a pair and the difference between the amount of refraction. The declinations of the stars adopted for this work are those of certain fundamental ones contained in Newcomb's catalogue. The positions of these stars are reduced to an absolute system and the values here used are considered to be definitive. The sum of the zenith distances have been obtained by observation with the meridian circle instrument, the difference of the refractions being deduced from a standard table. The tables here used are those which form an Appendix to the "Greenwich Observations" for the year 1853. These tables are constructed from Bessel's *Tabulæ Regiomontanæ;* assuming that the reading of the thermometer attached to the barometer is the same as the external one, this assumption will seldom lead to any sensible error.

The method here outlined has some advantages, firstly the complete elimination of the latitude and its variation; secondly the elimination of the nadir observations, since

$z'_n + z'_s$ the sum of the zenith distances is simply the difference of the circle readings, and is therefore independent of the zenith point; and finally the time necessary to obtain sufficient data does not extend over a long interval; also the simplicity of the reductions has much to commend the method.

The disadvantage in this method is that the declinations of the stars must be known. Taking fundamental stars and a large number reduces this difficulty, which will be almost eliminated in the final results.

Having obtained the refractions in the manner explained in the preceding paragraphs, the correction to the constant of the table can be deduced from the following equation [1]

$$dr = A\,d\alpha + B\,d\beta \quad\ldots\ldots\ldots 5$$

$$A = r/\alpha$$

$$B = \text{Sin}^2\, z \sqrt{\frac{2}{\beta}}\left(\frac{dq}{d\beta} - \frac{q}{2\beta}\right)$$

Consulting an investigation by Professor Comstock,[2] it will be noted that the effect of the higher powers of $\Delta\beta$, for the barometric pressures here used, and involved in the factor

$$\beta = \frac{b}{B} = 1 + \frac{b - B}{B} = 1 + \frac{\Delta b}{B}$$

need not be taken into account. The quantities neglected will not be sensible at zenith distances less than 80 degrees. In these reductions no modification of the factor of the refraction depending on the barometer need be made.

Therefore the coefficient $\beta$ is asumed to be correct or that

$$d\beta = o$$

Equation (5) reduces to the expression

$$dr = Ad\alpha = \frac{r}{\alpha}\,d\alpha$$

[1] Chauvenet. Vol. I., p. 672.

[2] Publications of the Lick Observatory, Vol. I.

hence we have

$$\frac{d\alpha}{\alpha} = \frac{dr}{r} \text{.........x}$$

therefore

$$d \log \alpha = d \log r \text{.........y}$$

In this manner we obtain $d \log r$ which equals $d \log \alpha$, hence obtaining $d\alpha$ from equation (x) or the correction to $\alpha$ of the tables.

## 6. Observations.

The following list of stars was observed between the dates 1905 July 3 and 1905 July 25 inclusive. For most pairs ten observations were obtained; in some cases, especially those at large zenith distances, as many as fourteen observations were taken. During the period of time occupied in obtaining the data for this investigation, about 512 zenith distances and 24 determinations of the nadir were taken, necessitating 2384 micrometer readings and 608 pointer indications. From this number only two observations of zenith distance had to be rejected.

Weights depending on the definition, and varying from 1 to 5, were assigned to each evening's work. These were used in the preliminary calculations and also in the discussion of the final ones obtained from the mean errors of observation.

The evening's work consisted in obtaining, as far as possible, the circle readings for each star given in the list, the nadir being taken just before and again at the conclusion of the observations. As stated previously, the nadir readings were not here necessary, but were taken for the object of deducing a value of the latitude of the meridian circle instrument; the results of this determination form the subject of a short paper to be later communicated to the Society.

No times were recorded during the transits of the stars, the whole attention being directed to bisecting the image of the object under observation, with the horizontal wire; the bisection was made at or near the intersection of the centre wire of the transit system with the horizontal thread. In a few cases this was impossible, but in no instance was it found necessary to apply a correction for curvature.

The positions of the stars given in the appended list are taken from Newcomb's "*Catalogue of Fundamental Stars for 1875 to 1900, Reduced to an Absolute System*," the numbers in the first column referring thereto. The positions here given were reduced to the epoch 1905, adopting Professor Newcomb's precessions and proper motions. The coefficients to be combined with the data of the ephemerides to obtain the reductions to apparent places were computed with the formulæ of the Nautical Almanac. The declinations of the stars between −77 degrees and the pole were corrected for terms of the second order by the formula

$$\delta - \delta_0 = \Delta\delta_0 - [6{\cdot}7367 - 10] \text{ Sin } \delta_0 \cos \delta \, \Delta\alpha_0^2$$

in which $\delta_0$ is the mean and $\delta$ the apparent declination, $\Delta\alpha_0$ $\Delta\delta_0$ being the star corrections exclusive of the second order terms. The number within the brackets is a logarithm.

The heavy type indicates that the star transits below the pole during the time of observation.

## STAR CATALOGUE.

| No. | α (h. m. s.) | δ (° ′ ″) | Proper Motion $\mu_\delta$ (″) | Log $a'$ | Log. $b'$ | Log. $c'$ | Log. $d'$ |
|---|---|---|---|---|---|---|---|
| 892 | 14 11 37·48 | − 83 13 59·33 | − 0·0136 | 9·6887$_n$ | 9·9210 | 1·2261$_n$ | 9·7350 |
| **148** | **2 20 3·33** | **−69 5 29·68** | + 0·0195 | 9·8394 | 9·8837$_n$ | 1·2153 | 9·7587$_n$ |
| 918 | 14 34 49·19 | − 64 33 42·06 | − 0·2387 | 9·5779$_n$ | 9·8480 | 1·1943$_n$ | 9·7961 |
| 927 | 14 41 4·81 | − 87 45 47·47 | − 0·0651 | 9·7986$_n$ | 9·8822 | 1·1846$_n$ | 9·8105 |
| 939 | 14 48 10·87 | − 82 39 29·80 | − 0·0636 | 9·7845$_n$ | 9·8672 | 1·1728$_n$ | 9·8259 |
| 946 | 14 51 44·14 | + 14 49 47·91 | − 0·0109 | 9·7735 | 9·2728$_n$ | 1·1666$_n$ | 9·8332 |
| 952 | 14 58 22·06 | + 40 45 54·09 | − 0·0399 | 9·8960 | 9·6674$_n$ | 1·1546$_n$ | 9·8464 |
| **198** | **3 1 0·34** | **−88 33 10·35** | + 0·0139 | 9·8579 | 9·8474$_n$ | 1·1496 | 9·8514$_n$ |
| **197** | **3 2 3·17** | **−72 16 24·41** | − 0·0263 | 9·9094 | 9·8244$_n$ | 1·1476 | 9·8533$_n$ |
| 958 | 15 5 19·44 | − 48 22 36·61 | − 0·0619 | 9·4024$_n$ | 9·7128 | 1·1412$_n$ | 9·8593 |
| 963 | 15 10 1·81 | − 68 19 44·53 | − 0·0415 | 9·7202$_n$ | 9·7978 | 1·1317$_n$ | 9·8677 |
| 971 | 15 17 43·75 | − 14 47 42·94 | + 0·0026 | 9·3530 | 9·2203 | 1·1152$_n$ | 9·8806 |
| 975 | 15 20 54·10 | + 37 42 36·28 | + 0·0814 | 9·9103 | 9·5925$_n$ | 1·1081$_n$ | 9·8857 |
| 980 | 15 23 54·74 | + 29 25 58·44 | + 0·0783 | 9·8806 | 9·4905$_n$ | 1·1011$_n$ | 9·8904 |
| 985 | 15 29 5·93 | + 31 40 46·18 | − 0·0247 | 9·8946 | 9·5070$_n$ | 1·0887$_n$ | 9·8982 |
| 986 | 15 30 12·64 | − 14 28 22·35 | + 0·0064 | 9·3456 | 9·1817 | 1·0860$_n$ | 9·8998 |
| 991 | 15 34 24·93 | + 40 39 44·75 | + 0·0483 | 9·9312 | 9·5873$_n$ | 1·0754$_n$ | 9·9058 |
| 994 | 15 36 28·25 | − 19 22 15·44 | − 0·1061 | 9·1477 | 9·2887 | 1·0700$_n$ | 9·9086 |
| 995 | 15 37 18·88 | + 19 58 33·42 | − 0·0582 | 9·8358 | 9·2993$_n$ | 1·0678$_n$ | 9·9098 |
| 1000 | 15 44 39·67 | − 3 8 23·33 | − 0·0279 | 9·5885 | 8·4843 | 1·0477$_n$ | 9·9194 |
| 1004 | 15 46 45·97 | − 63 8 16·31 | − 0·4074 | 9·7400$_n$ | 9·6901 | 1·0417$_n$ | 9·9221 |
| **246** | **3 48 42·16** | **−74 31 48·81** | + 0·1172 | 9·9664 | 9·7181$_n$ | 1·0361 | 9·9245$_n$ |
| 1023 | 15 6 7·68 | − 78 27 25·77 | − 0·0555 | 9·8890$_n$ | 9·6693 | 0·9803$_n$ | 9·9440 |
| 1030 | 16 9 21·97 | − 3 27 0·06 | − 0·1440 | 9·5795 | 8·4461 | 0·9687$_n$ | 9·9473 |
| 1033 | 16 13 17·61 | − 4 27 40·52 | + 0·0369 | 9·5599 | 8·5431 | 0·9542$_n$ | 9·9511 |
| 1037 | 16 17 15·58 | + 1 15 6·93 | + 0·0409 | 9·6565 | 7·9763$_n$ | 0·9389$_n$ | 9·9548 |
| 1041 | 16 18 51·59 | − 78 41 4·41 | − 0·0820 | 9·9039$_n$ | 9·6220 | 0·9326$_n$ | 9·9563 |
| 1046 | 16 21 1·70 | + 14 15 5·96 | − 0·0594 | 9·8089 | 9·0130$_n$ | 0·9238$_n$ | 9·9582 |
| **284** | **4 24 22·92** | **−80 26 12·47** | + 0·0719 | 9·9884 | 9·6016$_n$ | 0·9097 | 9·9611$_n$ |
| 1062 | 16 31 2·42 | + 42 37 57·38 | + 0·0260 | 9·9759 | 9·4088$_n$ | 0·8801$_n$ | 9·9664 |
| **293** | **4 33 52·53** | **−83 6 18·38** | + 0·0169 | 9·9893 | 9·5615$_n$ | 0·8667 | 9·9686$_n$ |
| 1069 | 16 39 38·32 | + 39 6 9·35 | − 0·0930 | 9·9680 | 9·3357$_n$ | 0·8379$_n$ | 9·9727 |
| 1080 | 16 49 30·74 | + 10 19 16·97 | − 0·0433 | 9·7764 | 8·7343$_n$ | 0·7831$_n$ | 9·9791 |
| 1083 | 16 52 0·51 | − 53 0 53·83 | − 0·0166 | 9·7015$_n$ | 9·3683 | 0·7679$_n$ | 9·9806 |
| 1086 | 16 56 3·05 | − 4 4 49·67 | − 0·0756 | 9·5615 | 8·2922 | 0·7420$_n$ | 9·9829 |
| **317** | **4 57 54·67** | **−75 4 59·40** | + 0·0550 | 0·0182 | 9·4126$_n$ | 0·7295 | 9·9839$_n$ |
| 1093 | 17 5 20·82 | − 43 6 52·02 | − 0·3059 | 9·5409$_n$ | 9·2080 | 0·6753$_n$ | 9·9875 |
| 1098 | 17 11 7·74 | + 24 57 3·21 | − 0·1582 | 9·9061 | 8·9507$_n$ | 0·6276$_n$ | 9·9901 |
| 1103 | 17 14 23·65 | + 37 23 26·80 | + 0·0586 | 9·9731 | 9·0793$_n$ | 0·5980$_n$ | 9·9913 |

## 7. Errors of Graduation of the Circle.

The errors of graduation of the circle, used in obtaining the observations, have never been adequately determined. A cursory examination of certain records found in the Observatory books seemed to indicate that the errors were not large, and that the circle is a fairly accurate one. In this connection no corrections have been applied to the observations used in this investigation. If circumstances permit, it is intended to examine the circles of this instrument. The results may form the subject of a future communication to the Society.

## 8. Reduction of the Observations.

The first operation was to take the mean of the four micrometer readings and apply the result to the reading of the pointer, hence the complete circle reading denoted by C in the tabular form prepared for the computation. The errors of runs of the micrometers were taken several times during the evening's work, but these never became appreciable. From the values of C the quantity $Y$ can now be formed. The terms $\delta'$ and $X$ being deduced from the declinations, see equations (3) and (4). All numerical work was checked, either by duplication or by differences in some cases.

The calculated refractions were obtained by computation from the tables, adopting the height of the barometer and temperature of the air for a stated time. To correct these quantities for the state of the air at the time of observation, a table was prepared, from which the corrections could be easily interpolated.

The following examples give the reductions in the case of the two stars 975 and 317. The same form was used for all pairs without exception.

Star 975
" 317

| 1905 | $\delta'$ | $X$ | $C$ | $Y$ | $r'_c$ | $\frac{1}{2}(r'_n - r'_s)$* | $\frac{1}{2}(X-Y)$ | $r_\circ$ | $p$ |
|---|---|---|---|---|---|---|---|---|---|
| | ° ′ ″ | ° ′ ″ | ° ′ ″ | ° ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | |
| July 3 | + 37 42 49·31 | | 79 56 42·30 | | 2 54·43 | | | 2 53·36 | 2 |
| " | - 104 55 2·91 | 142 37 52·22 | 222 28 52·65 | 142 32 10·35 | 2 49·59 | + 0 2·42 | 2 50·94 | 2 48·52 | 2 |
| " 4 | 49·45 | | 42·40 | | 2 54·89 | | | 2 53·93 | 2 |
| " | 3·27 | 52·72 | 51·90 | 9·50 | 2 50·26 | 2·32 | 51·61 | 2 49·29 | 2 |
| " 5 | 49·58 | | 38·05 | | 2 53·08 | | | 2 51 00 | 1 |
| " | 3·64 | 53·22 | 53·98 | 15·93 | 2 48·38 | 2·35 | 48·65 | 2 46 30 | 1 |
| " 7 | 49·87 | | 41·78 | | 2 54·51 | | | 2 52·13 | 1 |
| " | 4·35 | 54·22 | 56·20 | 14·42 | 2 50·05 | 2·23 | 49·90 | 2 47·67 | 1 |
| " 10 | 50·41 | | 37·98 | | 2 50·75 | | | 2 50·13 | 3 |
| " | 5·26 | 55·67 | 57·85 | 19·87 | 2 46·32 | 2·23 | 47·90 | 2 45·67 | 3 |
| " 12 | 50·77 | | 38·58 | | 2 53·37 | | | 2 52·49 | 2 |
| " | 5·82 | 56·59 | 54·65 | 16·07 | 2 48·91 | 2·23 | 50·26 | 2 48·03 | 2 |
| " 14 | 51·05 | | 41·00 | | 2 53·49 | | | 2 50·58 | 2 |
| " | 6·40 | 57·45 | 61·48 | 20·48 | 2 49·31 | 2·09 | 48·49 | 2 46·40 | 2 |
| " 15 | 51·17 | | 41·90 | | 2 54·80 | | | 2 51·86 | 2 |
| " | 6·71 | 57·88 | 60 93 | 19·03 | 2 49·94 | 2·43 | 49·43 | 2 47·00 | 2 |
| " 19 | 51·57 | | 41·02 | | 2 52·41 | | | 2 50·71 | 4 |
| " | 7·99 | 59·56 | 63·75 | 22·73 | 2 47·83 | 2·29 | 48·42 | 2 46·13 | 4 |
| " 21 | 51·79 | | 39·88 | | 2 50·96 | | | 2 50 31 | 4 |
| " | 8·59 | 60·38 | 64·33 | 24 45 | 2 46·28 | 2·34 | 47·97 | 2 45·63 | 4 |
| " 24 | 52·18 | | 38·80 | | 2 52·49 | | | 2 51·62 | 2 |
| " | 9·37 | 61·55 | 61·18 | 22·38 | 2 48·43 | 2·03 | 49·59 | 2 47·56 | 2 |
| " 25 | 52·31 | | 39·02 | | 2 51·60 | | | 2 50 52 | 3 |
| " | 9·61 | 61·92 | 64·18 | 25·16 | 2 47 32 | 2·14 | 48·38 | 2 46·24 | 3 |

* Negative sign applied to the tabular quantities will give $\frac{1}{2}(r'_s - r'_n)$.

Star 975
„ 317

| 1905. | Log $r_o$ | Log $r_c$ | $d$ log $r$ | $pv^2$ | $p$ |
|---|---|---|---|---|---|
| July 3 | 2·2389 | 2·2416 | −0·0027 | 0·00000098 | 2 |
| „ 4 | 2·2404 | 2·2428 | −0·0024 | 200 | 2 |
| „ 5 | 2·2330 | 2·2383 | −0·0053 | 361 | 1 |
| „ 7 | 2·2359 | 2·2418 | −0·0059 | 625 | 1 |
| „ 10 | 2·2308 | 2·2324 | −0·0016 | 972 | 3 |
| „ 12 | 2·2368 | 2·2390 | −0·0022 | 288 | 2 |
| „ 14 | 2·2319 | 2·2393 | −0·0074 | 3200 | 2 |
| „ 15 | 2·2352 | 2·2425 | −0·0073 | 3042 | 2 |
| „ 19 | 2·2323 | 2·2366 | −0·0043 | 324 | 4 |
| „ 21 | 2·2312 | 2·2329 | −0·0017 | 1156 | 4 |
| „ 24 | 2·2346 | 2·2368 | −0·0022 | 288 | 2 |
| „ 25 | 2·2318 | 2·2345 | −0·0027 | 147 | 3 |

$$d \log r = -0·0034$$
$$p = 28$$
$$\epsilon^2 = 0·00000035$$

Star 317
„ 975

| 1905. | Log $r_o$ | Log $r_c$ | $d$ log $r$ | $pv^2$ | $p$ |
|---|---|---|---|---|---|
| July 3 | 2·2267 | 2·2294 | −0·0027 | 0·00000162 | 2 |
| „ 4 | 2·2286 | 2·2311 | −0·0025 | 242 | 2 |
| „ 5 | 2·2209 | 2·2263 | −0·0054 | 324 | 1 |
| „ 7 | 2·2245 | 2·2306 | −0·0061 | 625 | 1 |
| „ 10 | 2·2192 | 2·2209 | −0·0017 | 1083 | 3 |
| „ 12 | 2·2254 | 2·2277 | −0·0023 | 338 | 2 |
| „ 14 | 2·2212 | 2·2287 | −0·0075 | 3042 | 2 |
| „ 15 | 2·2227 | 2·2303 | −0·0076 | 3200 | 2 |
| „ 19 | 2·2204 | 2·2249 | −0·0045 | 324 | 4 |
| „ 21 | 2·2191 | 2·2208 | −0·0017 | 1444 | 4 |
| „ 24 | 2·2242 | 2·2264 | −0·0022 | 392 | 2 |
| „ 25 | 2·2207 | 2·2236 | −0·0029 | 147 | 3 |

$$d \log r = -0·0036$$
$$p = 28$$
$$\epsilon^2 = 0·00000037$$

## 9. Final Results.

The following table gives the individual results for each pair. The approximate zenith distances are also tabulated. From the values of $\epsilon$, the weights, given in the fifth column, have been computed and which are now used in all subsequent combinations. The values of $\epsilon$ are in units of the fourth place of decimals.

| Stars. | z | d log r | ε | p |
|---|---|---|---|---|
| | ° | | ± | |
| 1004 – 1000 | 29·28 | + 0·0071 | 6·8 | 1·1 |
| 1004 – 1030 | 29·28 | + 0·0086 | 8·1 | 0·8 |
| 1004 – 1033 | 29·28 | + 0·0083 | 7·9 | 0·8 |
| 1004 – 1086 | 29·28 | + 0·0019 | 8·2 | 0·7 |
| 1033 – 918 | 29·40 | + 0·0017 | 7·6 | 0·8 |
| 1033 – 1004 | 29·40 | + 0·0083 | 7·8 | 0·8 |
| 1086 – 918 | 29·78 | – 0·0025 | 5·4 | 1·7 |
| 1086 – 1004 | 29·78 | + 0·0019 | 8·1 | 0·8 |
| | | | | |
| 1030 – 918 | 30·42 | + 0·0011 | 7·1 | 1·0 |
| 1030 – 1004 | 30·42 | + 0·0083 | 7·8 | 0·8 |
| 918 – 1030 | 30·70 | + 0·0012 | 7·0 | 1·0 |
| 918 – 1033 | 30·70 | + 0·0017 | 7·1 | 1·0 |
| 918 – 1086 | 30·70 | – 0·0024 | 5·1 | 1·9 |
| 918 – 1000 | 30·70 | + 0·0003 | 7·6 | 0·9 |
| 1000 – 1004 | 30·72 | + 0·0067 | 6·3 | 1·3 |
| 1000 – 918 | 30·72 | + 0·0004 | 7·6 | 0·9 |
| | | | | |
| 963 – 1037 | 34·47 | + 0·0017 | 6·6 | 1·1 |
| 1037 – 963 | 35·08 | + 0·0017 | 7·1 | 1·0 |
| | | | | |
| 1080 – 1023 | 44·18 | – 0·0003 | 3·7 | 3·6 |
| 1080 – 1041 | 44·18 | – 0·0022 | 1·4 | 25·0 |
| 1023 – 1080 | 44·60 | – 0·0003 | 3·7 | 3·6 |
| 1041 – 1080 | 44·82 | – 0·0022 | 1·4 | 25·0 |
| | | | | |
| 1046 – 939 | 48·12 | + 0·0052 | 1·4 | 25·0 |
| 1046 – 892 | 48·12 | – 0·0018 | 3·7 | 3·6 |
| 946 – 892 | 48·70 | – 0·0033 | 3·0 | 6·7 |
| 946 – 939 | 48·70 | + 0·0035 | 2·4 | 8·3 |
| 939 – 1046 | 48·80 | + 0·0051 | 1·4 | 25·0 |
| 939 – 946 | 48·80 | + 0·0035 | 2·2 | 10·0 |
| 892 – 1046 | 49·38 | – 0·0017 | 3·6 | 3·8 |
| 892 – 946 | 49·38 | – 0·0032 | 2·8 | 6·3 |

| Stars. | z | d log r | ε | p |
|---|---|---|---|---|
| | ° | | ± | |
| 198 – 1098 | 57·58 | – 0·0001 | 2·8 | 6·3 |
| 1098 – 198 | 58·82 | 0·0000 | 2·8 | 6·3 |
| | | | | |
| 294 – 980 | 63·03 | – 0·0015 | 2·0 | 13·0 |
| 980 – 294 | 63·30 | – 0·0014 | 2·0 | 13·0 |
| 985 – 284 | 65·55 | – 0·0043 | 2·6 | 7·1 |
| 284 – 985 | 65·70 | – 0·0043 | 2·6 | 7·1 |
| | | | | |
| 317 – 1103 | 71·05 | – 0·0027 | 2·0 | 13·0 |
| 317 – 975 | 71·05 | – 0·0036 | 2·0 | 13·0 |
| 1103 – 317 | 71·25 | – 0·0027 | 2·0 | 13·0 |
| 1103 – 246 | 71·25 | – 0·0023 | 1·4 | 25·0 |
| 975 – 317 | 71·58 | – 0·0034 | 2·0 | 13·0 |
| 975 – 246 | 71·58 | – 0·0031 | 1·7 | 16·7 |
| 246 – 1103 | 71·62 | – 0·0023 | 1·0 | 50·0 |
| 246 – 975 | 71·62 | – 0·0030 | 1·7 | 16·7 |
| | | | | |
| 1069 – 197 | 72·97 | – 0·0027 | 2·7 | 7·1 |
| 197 – 952 | 73·87 | – 0·0016 | 3·2 | 5·0 |
| 197 – 991 | 73·87 | – 0·0016 | 2·8 | 6·3 |
| 197 – 1069 | 73·87 | – 0·0026 | 2·7 | 7·1 |
| | | | | |
| 991 – 197 | 74·53 | – 0·0016 | 2·6 | 7·1 |
| 952 – 197 | 73·63 | – 0·0015 | 3·0 | 5·6 |
| 1062 – 148 | 76·50 | – 0·0028 | 1·0 | 50·0 |
| 148 – 1062 | 77·05 | – 0·0027 | 1·0 | 50·0 |

Combining the results into normals, as indicated in the arrangement of the preceding table, we have the following statement.

| z | d log r | p |
|---|---|---|
| ° | | |
| 29·44 | + 0·00372 | 7·5 |
| 30·65 | + 0·00175 | 8·8 |
| 34·76 | + 0·00170 | 2·1 |
| 44·49 | – 0·00196 | 57·2 |
| 48·63 | + 0·00300 | 88·7 |
| 58·20 | – 0·00005 | 12·6 |
| 64·04 | – 0·00245 | 40·2 |
| 71·43 | – 0·00271 | 160·4 |
| 73·62 | – 0·00218 | 25·5 |
| 76·69 | – 0·00261 | 112·7 |

From which we obtain

$$d \log r = -0{\cdot}00132 \pm 50$$

$$p = 515{\cdot}7$$

## 10. The Constant of Refraction.

The value of $\alpha$, the constant of refraction used by Bessel in forming the table of refractions, *Tabulæ Regiomontanæ*, is

$$\alpha = 0{\cdot}00027895 = 57''{\cdot}538$$

This is for barometer 29·6 inches, $t = t' = 50°$ In the tables used in this investigation, no information is given with regard to any alteration of these values, so they are here adopted.

$$d \log r = dr/r = -0{\cdot}00132$$

therefore $$d\alpha = -0{\cdot}00132\alpha$$

$$= -0{\cdot}''076$$

and $$\alpha = 57{\cdot}''462$$

This reduced to the condition 760 mm. pressure at 0° and temperature 0° C. gives

$$\alpha = 60{\cdot}''283$$

$$u = 1{\cdot}0002924$$

Appended will be found a list of the most important determinations of the constant of refraction. These values are for the conditions B equals 760 mm. at 0° C., the external thermometer 0° C.

| | $\alpha$ | $u$ |
|---|---|---|
| 1. Tables Pulkowa ... | 60″·268 | 1·0002923 |
| 2. Fuess ... ... | 60·122 | 2916 |
| 3. Greenwich 1857-65 | 60·120 | 2916 |
| 4. Pulkowa 1865 ... | 60·209 | 2920 |
| 5. Greenwich 1877-86 | 60·192 | 2920 |
| 6. Pulkowa 1885 ... | 60·058 | 2913 |
| 7. Munich ... ... | 60·104 | 2915 |

Mean values.

$$\alpha = 60{\cdot}''153 \qquad u = 1{\cdot}0002918$$

The following is a short summary of the values of $u$ determined by laboratory experiments:

| | $u$ |
|---|---|
| 1. Mascart 1877 ... ... ... | 1·0002927 |
| 2. Lorentz 1880 ... ... ... | 2911 |
| 3. Bénoit 1888 ... ... ... | 2923 |
| 4. Chappuis and Rivière 1888 ... | 2919 |
| 5. Kayser and Runge 1893 ... ... | 2922 |

$$u = 1 \cdot 0002920$$

On examination of the normals, giving the values of $d \log r$, it is quite evident that these quantities vary with the zenith distance. This would seem to denote that the so called constant of refraction, adopted in forming the tables, not only needs correction but also a correction for every zenith distance.[1]

Now denoting by $Z$ the zenith distance for $d \log r$ equals nought, we may form equations of condition of the following type,

$$\operatorname{Log} \alpha_o - \log \alpha_c = d \log r = [Z - z]\, x$$

or
$$y - zx - d \log r = 0$$

in which
$$y = Zx \ldots\ldots\ldots 6$$

and $\log \alpha_c$ is the value used in the tables. The suffixes denote observation and calculation respectively. In this way the following condition equations are formed after multiplying each by the square root of the weight of the absolute term.

$$\begin{aligned}
2{\cdot}7\; y &- 79{\cdot}5\; x - 0{\cdot}01004 = 0 \\
3{\cdot}0 \;\; &- 92{\cdot}0 \;\;\;\; - 0{\cdot}00525 = 0 \\
1{\cdot}5 \;\; &- 52{\cdot}1 \;\;\;\; - 0{\cdot}00255 = 0 \\
7{\cdot}6 \;\; &- 338{\cdot}1 \;\;\; + 0{\cdot}01490 = 0
\end{aligned}$$

[1] A similar conclusion has been arrived at by Mr. R. Tracy Crawford. To his thesis on the "Determination of the Constant of Refraction" I am much indebted. See Proceedings of the California Academy of Sciences, Vol. I.

$$\begin{array}{rrrl}
9{\cdot}4\ y - & 457{\cdot}1\ x - & 0{\cdot}02820 & = 0 \\
3{\cdot}5 & -\ 203{\cdot}7 & +\ 0{\cdot}00018 & = 0 \\
6{\cdot}3 & -\ 403{\cdot}5 & +\ 0{\cdot}01544 & = 0 \\
12{\cdot}7 & -\ 907{\cdot}2 & +\ 0{\cdot}03442 & = 0 \\
5{\cdot}0 & -\ 368{\cdot}1 & +\ 0{\cdot}01090 & = 0 \\
10{\cdot}6 & -\ 812{\cdot}9 & +\ 0{\cdot}02767 & = 0
\end{array}$$

To make these equations more nearly homogeneous, put

$$\left.\begin{array}{r} y = y \\ 100x = v \end{array}\right\} \ldots\ldots\ldots 7$$

and multiply the absolute term by 100.

Reducing by the method of least squares, the following system will be found, and from which the values of $y$ and $v$ can be determined, hence obtaining the quantities $x$ and $Z$.

$$515{\cdot}250\, y - 326{\cdot}688\, v + 68{\cdot}4315 = 0$$
$$-326{\cdot}688\, y + 216{\cdot}437\, v - 54{\cdot}7312 = 0$$

Remembering that the absolute term was multiplied by 100, the following result from the solution.

$$\text{Log } v = 8{\cdot}0860357 \qquad \text{Log } y = 7{\cdot}8062727$$
$$v = 0{\cdot}0122 \qquad y = 0{\cdot}0064$$
$$[pvv] = 0{\cdot}0011673923$$
$$m - u = 8$$
$$\text{Log } p_y = 1{\cdot}3453805 \qquad \text{Log } p_v = 0{\cdot}9686940$$
$$\text{Log } r_{,} = 7{\cdot}9110368$$
$$r_v = \pm\, 0{\cdot}0027 \qquad r_y = \pm\, 0{\cdot}0017$$

From equations (6) and (7) we may now find $Z$ and $x$.

$$Z = 52^{\circ}{\cdot}5093 = 52^{\circ}\ 30'\ 33''$$
$$x = 0{\cdot}000122$$
$$\text{Log } \alpha_o = \text{Log } \alpha_c + \mathbf{0{\cdot}000122}\ [\mathbf{52^{\circ}\ 30'\ 33''} - z]$$

### 11. Conclusion.

During the reductions, it was very noticeable the manner in which the observed refractions varied in accordance with the computed ones, due to the alteration in the state of the atmosphere. If observations of zenith distance of

stars are taken between limits of time, separated by some hours, greater accuracy in the reductions, to obtain the correct positions, can be attained, by taking fully into consideration the fluctuations of the height of the barometer, and *especially* the variations of the temperature indicated by the readings of the thermometer, when computing the refractions for a series of observations that extend over some hours of time. Adopting the state of the atmosphere for a mean of the times of observations does not seem sufficient. The refraction tables in use at this Observatory would represent the observed refractions better, if a correction[1] be applied to them for the difference in the force of gravity at Greenwich[2] and Sydney represented by the equation

$$\Delta \log \alpha = 0{\cdot}00225 \text{ Sin } (\phi' - \phi) \text{ Sin } (\phi' + \phi)$$

And further the refraction corrections computed from the Pulkowa tables, with a similar correction applied, would no doubt represent the observed refractions of the Sydney Observatory, much better than those of Bessel.

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[1] The theory of this correction, which is neglected in text books, is as follows:—The corresponding heights of the barometric column will be inversely proportional to the force of gravity, assuming equal density of the atmosphere at two places, the latitudes of which are $\phi$ and $\phi'$, that is

$$p : p' :: g' : g :: 1 - a \cos 2\,\phi' : 1 - a \cos 2\,\phi$$

from which

$$\text{Log}\, p = \text{Log}\, p' + 2\,aM \text{ Sin } (\phi' - \phi) \text{ Sin } (\phi' + \phi).$$
$$M = 0{\cdot}4343 \text{ and } a = 0{\cdot}0026.$$

Now the quantity $p$ in the above expressions is contained as a factor in the coefficient $B$ of the refraction tables, so we may therefore write, in units of the fifth decimal place,

$$\text{Log } B = \text{Log } B' + 225 \text{ Sin } (\phi' - \phi) \text{ Sin } (\phi' + \phi).$$

Tables that give a correct value of log $B$, for a latitude $\phi$, when used at another latitude, denoted by $\phi'$, will furnish a value of log $B'$, that should be corrected by the last term of the preceding equation. For most purposes this term may be united with the value of $\alpha$ of the tables, thus

$$\Delta \log \alpha = 225 \text{ Sin } (\phi' - \phi) \text{ Sin } (\phi' + \phi).$$

[2] Bessels' table of refractions, given in the *Tabulæ Regiomontanæ*, are prepared with a value of $\alpha$ derived from Bradley's observations made at Greenwich during the years 1750 and 1762.

# LATITUDE OF THE SYDNEY OBSERVATORY.

By C. J. MERFIELD, F.R.A.S.,

Mitglieder der Astronomischen Gesellschaft.

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

1. Introduction.
2. Observation and Methods.
3. Details of Results and the final deductions.
4. Conclusion.

This forms an appendix to a paper[1] on the "Provisional Determination of Astrónomical Refraction, from observations made with the Meridian Circle Instrument of the Sydney Observatory."

## 1. Introduction.

The adopted latitude of the Sydney "Meridian Circle Instrument" is

$$\phi_0 = -33^\circ\ 51'\ 41''\!.1$$

and this value has been used for many years—since 1860—in all reductions of observations made at the Observatory. The above value of the latitude was determined by the Rev. W. Scott, M.A.,[2] with a transit instrument, during the month of June 1859. The method used in the investigation, was to observe the zenith distance of a star, and after correcting the observation for refraction, this distance was added to or subtracted from its tabular north polar distance, according as it was north or south of the zenith; the result diminished by 90 degrees, represented the numerical value of the observed latitude.

[1] This Journal, Vol. xxxix., p. 76.

[2] The Government Astronomer for New South Wales during the years 1856-62.

During the years 1859-60-61,[1] the observed north polar distances of certain Nautical Almanac stars were compared with the tabular ones. The residuals obtained were assumed to represent corrections to the latitude adopted in the reduction of the observations.

From the several volumes mentioned in the foregoing paragraph, the following data have been deduced:

| Year. | $\phi_0$ | No. of Observations. |
|---|---|---|
| (June) 1859 | $-33^\circ\ 51'\ 41''\!.10$ | ... |
| 1859 | $-33\ \ 51\ \ 40{\cdot}87$ | 280 |
| 1860 | $-33\ \ 51\ \ 41{\cdot}27$ | 316 |
| 1861 | $-33\ \ 51\ \ 41{\cdot}61$ | 164 |

If the last three values are combined, according to the number of observations, then the result is

$$\phi = -33^\circ\ 51'\ 41''\!.21$$

The same result is obtained by a combination of the four values giving to each an equal weight.

Although the Rev. Mr. Scott, subsequent to the year 1861, adopted a value of the latitude (which is still used) he seems to have been inclined to favour a value numerically greater; his own observations confirm this view. From the date 1861 to 1904 no further investigations have been made into this question. The appended determination is to be considered a provisional one, for reasons to be noted in the paper previously cited.

## 2. Observations and Methods.

The observations, taken for the purpose of obtaining values of the observed refractions by the method of equal zenith distances, are available for a determination of the

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[1] "Astronomical Observations made at Sydney Observatory, 1859-60-61," by W. Scott, M.A.

latitude, providing the position, on the circle, of the line passing through the zenith is known. In order that the observations, above noted, could be used for this object, the nadir was observed each evening. Two observations were taken, one before and another after the evening's work, a mean of the two was generally adopted in the reductions to find the zenith distances from the circle readings.

The fundamental equations used in these papers are

$$\delta'_n = \phi + (z'_n + r'_n)$$

$$\delta'_s = \phi - (z'_s + r'_s)$$

If we put $z$ to denote the zenith distance corrected for refraction, then

$$\phi = \tfrac{1}{2}(\delta'_n + \delta'_s) - \tfrac{1}{2}(z_n - z_s)$$

in which $\delta'_n$ $\delta'_s$ have the same significance as previously adopted, namely the distance from the equator measured along a great circle at right angles thereto, positive towards the north.

From the foregoing equation, values of the latitude were deduced and combined in a manner to be shown. It will be noted that the latitude obtained from this equation is independent of the absolute value of the refractions. The error of the difference of the computed refractions for each zenith distance, as determined from tables, still remains, but if the difference $z'_n - z'_s$ is small, the error in this connection can be neglected. The accuracy of the latitude determined in this way depends in a large degree on the exactness of the adopted declination of the stars observed. In this investigation, the data have been taken from Newcomb's "Catalogue of Fundamental Stars for 1875 and 1900, reduced to an Absolute System" and are adopted as definitive.

## 3. Details of Results and the Final Deductions.

$$-\phi = 33^\circ\ 51'\ 40'' + x$$

| Stars. | | Number of Observations | $x_0$ | $p$ | $px_0$ | $v = x_0 - x$ | $p.v.^2$ |
|---|---|---|---|---|---|---|---|
| 971 – | 1083 | 7 | 2″73 | 1·7 | 4·641 | + 1″04 | 1·839 |
| 986 | 1083 | 8 | 2·37 | 3·0 | 7·110 | + 0·68 | 1·387 |
| 1000 | 918 | 10 | 0·86 | 2·0 | 1·720 | – 0·83 | 1·378 |
| 1030 | 918 | 9 | 0·63 | 1·4 | 0·882 | – 1·06 | 1·573 |
| 1033 | 918 | 10 | 0·80 | 1·7 | 1·360 | – 0·89 | 1·347 |
| 1086 | 918 | 7 | 0·99 | 2·7 | 2·673 | – 0·70 | 1·323 |
| 1000 | 1004 | 10 | 1·46 | 2·7 | 3·942 | – 0·23 | 0·143 |
| 1030 | 1004 | 9 | 1·30 | 2·4 | 3·120 | – 0·39 | 0·365 |
| 1033 | 1004 | 10 | 1·40 | 2·9 | 4·060 | – 0·29 | 0·244 |
| 1086 | 1004 | 7 | 1·35 | 6·8 | 9·180 | – 0·34 | 0·786 |
| 946 | 892 | 7 | 1·45 | 3·7 | 5·365 | – 0·24 | 0·213 |
| 1046 | 892 | 4 | 1·10 | 3·0 | 3·300 | – 0·59 | 1·044 |
| 946 | 939 | 10 | 2·32 | 3·4 | 7·888 | + 0·63 | 1·349 |
| 1046 | 939 | 7 | 1·95 | 8·9 | 17·355 | + 0·26 | 0·602 |
| 975 | 246 | 12 | 2·19 | 3·5 | 7·665 | + 0·50 | 0·875 |
| 1103 | 246 | 12 | 1·52 | 2·4 | 3·648 | – 0·17 | 0·069 |
| 975 | 317 | 12 | 2·11 | 3·5 | 7·385 | + 0·42 | 0·617 |
| 1103 | 317 | 12 | 1·49 | 4·0 | 5·960 | – 0·20 | 0·160 |
| 952 | 197 | 9 | 2·13 | 1·6 | 3·408 | + 0·44 | 0·310 |
| 991 | 197 | 8 | 1·67 | 3·3 | 5·511 | – 0·02 | 0·001 |
| 1069 | 197 | 12 | 2·10 | 2·2 | 4·620 | + 0·41 | 0·370 |
| 994 | 958 | 5 | 1·16 | 5·1 | 5·916 | – 0·53 | 1·433 |
| 1037 | 963 | 10 | 1·69 | 5·2 | 8·788 | 0·00 | 0·000 |
| 1080 | 1023 | 9 | 2·52 | 1·8 | 4·536 | + 0·83 | 1·240 |
| 1080 | 1041 | 9 | 2·27 | 1·8 | 4·086 | + 0·58 | 0·606 |
| 1098 | 198 | 11 | 1·42 | 2·9 | 4·118 | – 0·27 | 0·211 |
| 985 | 284 | 10 | 2·49 | 2·0 | 4·980 | + 0·80 | 1·280 |
| 980 | 294 | 10 | 2·33 | 2·4 | 5·592 | + 0·64 | 0·983 |
| 1062 | 148 | 10 | 1·77 | 1·7 | 3·009 | + 0·08 | 0·011 |

*The weights have been computed from the mean errors of observation in the usual manner.*

From the preceding table the following are obtained

$[p] = 89{\cdot}7 \qquad [px_0] = 151{\cdot}818 \qquad \text{Log: } [pv^2] = 1{\cdot}33766$

Therefore

$$x = 1{\cdot}''692 \pm 0{\cdot}''06$$

$$\phi = -\ 33^\circ\ 51'\ 41{\cdot}''69 \quad \text{Epoch 1905 July 12.}$$

To obtain the mean latitude a reduction to this quantity is necessary.

Adopting the elements given by Chandler in the *Astronomical Journal*, Vol. XVII., No. 406, the following variations

of the mean latitude at Sydney, have been calculated for the period 1905 July 1 to August 2.

| Greenwich. Mean Noon. | $\phi - \phi_0$ ″ |
|---|---|
| 1905 July 1 | — 0·134 |
| „ 5 | — 0·138 |
| „ 9 | — 0·142 |
| „ 13 | — 0·145 |
| „ 17 | — 0·147 |
| „ 21 | — 0·149 |
| „ 25 | — 0·150 |
| „ 29 | — 0·151 |
| „ 33 | — 0·151 |

From the above data the latitude variation, for the epoch 1905 July 12, can be found by inspection. Applying this correction, with sign changed, to the preceding value of $\phi$, we obtain the mean latitude of the Sydney Meridian Instrument.

$$\phi_0 = -33^\circ\ 51'\ 41\cdot''55 \pm 0\cdot''06$$

## 4. Conclusion.

From a combination of all the available data, it must be conceded that the accepted value of the mean latitude of the Sydney Observatory is numerically too small. The probability is that the latitude now adopted is within one quarter of a second of the correct value, but, until further evidence is forthcoming, an alteration in the published value would be unjustifiable. This adopted latitude however can only be taken as provisional, and not as a definitive value of this important co-ordinate. A definitive determination of the latitude of the Sydney Observatory is worthy of due consideration. If it were ever decided to undertake such work, then the observations should be made at intervals extending over a long period of time, so that the data could be used not only for the determination of the mean latitude, but also for an investigation into the variation of this co-ordinate. For this purpose the author would advocate the construction of an instrument specially for the object in view.

# A METHOD OF SEPARATING THE CLAY AND SAND IN CLAY SOILS, AND THOSE RICH IN ORGANIC MATTER.

By L. COHEN, Chemical Laboratory, Department of Agriculture.

(Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

CONSIDERABLE difficulty has always been experienced in effecting the complete separation of the clay and sand fractions of those soils that contain above the average either of clay or organic matter. The chief obstacle to an exact mechanical analysis of the fine soil appears to be that the particles of clay form themselves into aggregates, very often having a minute vegetable fibre as a nucleus, and these aggregates behave in the elutriator as though they were sand grains of the same dimensions. This property possessed by organic matter or humus of cementing together the clay particles, though rendering, as a rule, the texture of the clay soils (*in situ*) more open, interferes considerably with the correct estimation of the constituent particles of the soil.

The method of preparation of a sample of soil usually employed in order to separate the clay by the action of a moving current of water is as follows :—A weighed portion is passed through a sieve which retains the stones, coarser root fibres, and gravel, and the fine soil is boiled with water until the clay particles are completely separated from the sand, and the floccules broken up. In this laboratory the sieve used allows all particles to pass through of a diameter of $\frac{1}{50}$ of an inch or less. If necessary, and this is the case

with nearly all humus soils, heavy loams, and clays, the soil is rubbed through by the fingers into a large basin with the aid of water. After allowing the fine soil to settle for half an hour, the supernatant turbid water is poured off, the residue washed into an Erlenmeyer flask and boiled for half an hour or more, according to the texture of the soil. After cooling, the contents of the flask are removed to the elutriator. A Schultze's elutriating vessel of conical shape is used, $3\frac{1}{2}$ inches in diameter at top and 6 inches deep, fitted with a brass rim, holder for funnel-tube, and overflow tube. The water is allowed to flow from a reservoir by means of a rubber tube delivering into a thistle-head tube, 15 in. long, leading down to half an inch of the bottom of the vessel, where it is drawn out into a small orifice. The rubber tube is about $\frac{1}{8}$ inch in diameter and provided with a screw-clamp to regulate the flow so as to keep the thistle tube full to the head.

When the water from the overflow tube is quite limpid, the clamp is screwed tight, the residual sand allowed to settle, the water poured off, and the sand then washed out into a basin and dried on the water-bath. This process produces good results with sandy soils and light loams containing up to about 30% of clay; where, however, this amount is exceeded, as a general rule the preliminary treatment by boiling with water alone does not yield satisfactory figures. To remedy this, several methods have been used in order to more completely break up the clay floccules into their constituent particles, of which perhaps the most efficient is that of rubbing the soil in a mortar by means of a caoutchouc pestle with a little water.

The process is very tedious and there is a decided tendency to underestimate the amount of sand present, owing to the necessity of pouring off at intervals the clay in suspension and adding fresh quantities of water. Schöne

recommends boiling the soil with a one to two per cent. solution of caustic alkali. A large quantity of clay as well as fibre is present in the residue remaining in the elutriator after the treatment of soils by the above methods, especially in the case of peaty soils or those containing from about 15% and upwards of organic matter. It seemed then that the difficulty would be overcome and the complete disintegration of the clay floccules brought about by subjecting the soil to the action of some substance before elutriation, which would dissolve the cellulose of which the fibre mainly consists.

A solution of zinc chloride in twice its weight of hydrochloric acid (40% HCl) was found to be the most convenient solvent, the ammoniacal cupric hydrate being unsuitable for the purpose. Thirty grams of a peaty soil from Bundanoon containing 22·27% of organic matter, were passed in a dry state through a wire sieve having 50 meshes to the inch. The fine soil was then boiled for half an hour in a beaker with 200 cc. of the zinc chloride reagent, and after dilution the whole was washed into the elutriating vessel. After five minutes the overflow water became perceptibly clearer, and in three quarters of an hour was perfectly clear. The weight of the residue on drying was 1·85 gram, equivalent to 6·17% of sand in the soil, the clay percentage being calculated by difference.

For purposes of comparison, 30 grams of the same soil, after being passed through the sieve, were boiled with water for 45 min. Three hours and a half elapsed before the overflow became quite free from turbidity, and the dried residue was found to weigh 17·1 gram; in other words, by this treatment the soil is estimated to contain 57% of sand. On examination of the two residues, that from the zinc chloride treatment was found to consist of nothing but clean, hard, sharp grains of sand with no perceptible

admixture of clay. On the other hand, by the water process the residual "sand" was almost entirely made up of clay floccules of the dimensions of medium sand grains, each floccule or aggregate appearing to be composed of minute particles of decayed vegetable matter to which adhered clay and particles of sand. The heavier sand grains were observed to settle down rapidly after the current of water was stopped, but the major portion of the sand was distributed throughout the clay etc. which deposited more slowly. In order to compare the disintegrating power on the clay floccules, of the zinc chloride reagent, and the 2% alkali solution recommended by Schöne[1] for soils rich in humus, 30 grams of the same soil were boiled in 250 cc. of a two per cent. solution of caustic soda for 1 hour, the gravel etc., having been previously removed as in the other cases.

Great care was necessary to keep stirring before coming to the boil, as the soil becomes very flocculent and settles rapidly. The elutriation took 8 hours, the dried residue weighing 6·4 gram equivalent to 21·3% of sand in the soil. The appearance of the "sand" presented the same defects as those observed in the water process, though in a lesser degree. Apparently the effect of the alkaline hydrate is beneficial to a certain extent, dissolving the *humus* which has a binding effect on the clay particles, but exerting no solvent action on the vegetable fibre itself (cellulose). The superiority is apparent therefore of a reagent that will eliminate both these causes of adhesion of the particles.

In order to test the value of strong nitric acid in this direction, 30 grams of the fine soil were boiled in the strong acid for one hour. The reaction in this case is very violent and there is great difficulty in preventing the whole from frothing out of the vessel, great care being required,

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[1] Wiley *Agr. Analysis*, Vol. I., page 219.

especially on first warming. On dilution with water, gummy masses (cellulose nitrate) separate out, and are an obstacle to proper manipulation. The soil treated in this way required 3 hours to elutriate, the weight of residue being 5·9 grams. The latter in this case was cleaner than that produced by the alkali method, but still contained considerable quantities of clay and organic matter. Thirty grams of the same soil were also treated by heating with dilute hydrochloric acid to boiling in a beaker, powdered potassium chlorate being cautiously added, a little at a time, as the reaction is violent and attended by the escape of large quantities of chlorine. The boiling was continued for half an hour, and on elutriation 4·5 gram of residue remained, possessing the characteristics of that from the previous experiment. The overflow water became quite clear in 1 hour 45 minutes.

A stiff yellow clay soil from the Dorrigo Scrub, from which by boiling with water it was impossible to obtain reasonable figures for the sand and clay percentages, was treated by boiling 30 grams with 150 cc. of the zinc chloride reagent for half an hour. The elutriation in this case took 15 hours, but the residue after this time was a pure, clean, sharp sand, the grains varying considerably in size, entirely free from both clay and fibre, and weighing 2·8 gram, making 9·3%. The same soil by the pestling process yielded 1·6 gram sand, showing the very considerable loss of sand that occurs in this method. This soil contained a rather large amount of organic matter, viz., 15·66%, though from its appearance and physical properties, it could not be classed as a humus soil.

Most of the soils from the Myall Creek Estate, recently thrown open for settlement, presented much difficulty in the mechanical analysis, and the most unpromising of these, an exceedingly stiff black clay, was selected in order to

test the effect of the zinc chloride reagent. The soil, after pestling for some five hours, had yielded 9·2% of sand. Being too stiff to pass through the 50 mesh sieve in a dry state, 30 grams were allowed to soak in water for 15 minutes, and being by this time softened, were rubbed through the sieve into a large porcelain basin. After standing for half an hour the supernatant liquid was poured off, and the soil washed by means of 200 cc. of the zinc chloride reagent into a beaker. Forty-five minutes were allowed for boiling and the elutriation took 4 hours. The residue was of a whitish colour, and, observed under the microscope, was seen to consist of both rounded and sharp perfectly clean grains, of varying size, no fibre or clay particles being present, and weighing 8·55 grams.

The use of a solution of zinc chloride as described above will therefore be seen to be of great service in estimating the sand and clay in all soils with which other methods of treatment, preliminary to elutriation, give unsatisfactory results. Speaking generally, all heavy loams and clay soils as well as those containing more than the average quantity of organic matter, such as humus and peaty soils, may with benefit be treated by boiling with a solution of zinc chloride in twice its weight of hydrochloric acid, previous to elutriation in any of the usual apparatus.

Table showing the percentage of sand obtained on elutriation of four typical soils, after treatment with various reagents.

| Soil. | Organic matter per cent. | Percentage of Sand. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Boiling with $ZnCl_2$ in HCl | Boiling with Water. | Boiling with 2% Soda | Boiling with strong $HNO_3$ | Boiling with HCl and $KClO_3$ | Pestling. |
| Peaty soil from Bundanoon | 22·7 | 6·17 | 57·0 | 21·3 | 19·7 | 15·0 | |
| Stiff yellow clay from Dorrigo Scrub | 15·7 | 9·3 | 34·2 | 16·6 | 14·0 | ... | 5·3 |
| Stiff black clay from Myall Creek | 8·6 | 28·5 | ... | ... | ... | ... | 9·2 |
| Swampy soil from near Manly | 35·9 | ·7 | 48 2 | 5·3 | 7·0 | ... | |

# SOCIOLOGY OF SOME AUSTRALIAN TRIBES.

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Corres. Memb. Anthrop. Soc. Washington, etc.

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

## Introductory.

In 1894, when writing of the marriage systems of certain Australian tribes, I said: "Among the social institutions of a primitive people there is none of greater interest and value to the anthropologist than the study of these social systems."[1] At different times since then I have published a number of articles on the social and other customs of aboriginal tribes in all parts of Australia, but there still remains much unbroken ground in this branch of science.

Last year I reported for the first time certain subdivisions among the Ngeumba and Kamilaroi tribes,[2] which had quite escaped the observation of all previous writers. I now report for the first time the entire absence of exogamy among the Wongaibon, Kamilaroi, Ngeumba, Wirraidyuri, Barkunjee and other tribes in New South Wales and Victoria. I shall also endeavour to briefly explain the regulations regarding marriage among some tribes in Central Australia. A perusal of these pages will, it is thought, show the fallacy of the hitherto accepted belief in exogamy among Australian tribes and abrogate all the old-school notions respecting their sociology generally.

In any of my previous articles, whether published in this Journal or elsewhere, in which it may be stated that an aboriginal community comprises 'two exogamous divisions,'

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[1] *Proc. Roy. Geog. Soc.*, (Queensland) x., p. 18.

[2] This Journal, xxxviii., pp. 209 and 214.

the reader is requested to substitute 'two principal divisions.'

## Sociology of the Wombaia Tribe.

In illustrating this important subject I shall begin with the sociology of the Wombaia tribe, which occupies a large area on Cresswell Creek and Burnett Downs in the Northern Territory. It will be necessary to repeat a table showing the subdivisions of these people.[1] We shall see by this table that the eight sections of women can be classified genealogically into two distinct sets, which we may distinguish as cycles, each set comprising four specific sections of women in the column headed "Wife." Each of the two cycles reproduces its own four sections in a certain rotation and has perpetual succession, as follows:

TABLE I.

| Phratry. | Husband. | Wife. | Son. | Daughter. |
|---|---|---|---|---|
| A | Choolum | Ningulum | Palyarin | Palyareenya |
| | Jamerum | Palyareenya | Chooralum | Nooralum |
| | Cheenum | Nooralum | Bungarin | Bungareenya |
| | Yacomary | Bungareenya | Chingulum | Ningulum |
| B | Chingulum | Noolum | Yacomary | Yacomareenya |
| | Bungarin | Yacomareenya | Cheenum | Neenum |
| | Chooralum | Neenum | Jamerum | Neomarum |
| | Palyarin | Neomarum | Choolum | Noolum |

I consider this the best form in which to prepare a table of the eight section names. The four women of a cycle are placed by themselves, and the quartette of men who are their normal husbands are set down opposite to them. This is the same arrangement which I have adopted in tables illustrating the Kamilaroi, Wongaibon, Wirraidyuri, and other tribes. I have also used similar tables in describing the Yungmunni, Chingalee, Warramonga, Jarrau and other tribes with eight divisions in their social structure in Central and Western Australia.

[1] This Journal, xxxii., p. 75.

I provisionally call each of the cycles a phratry. Then in studying the upper half or Phratry A of the above table, we see that the women in the "wife" and "daughter" columns reproduce each other in a fixed order. The daughters belong to the same phratry or cycle as their mothers but to a different section of it. For example, Ningulum has a daughter Palyareenya; Palyareenya's daughter is Nooralum; Nooralum produces Bungareenya; Bungareenya is the mother of Ningulum, being the section name with which we started, and this series is continually repeated, no matter which name we commence with. Let us designate this series as "Cycle Z." If we take the women in the "Wife" column of Phratry B it is found that Noolum is the mother of Yacomareenya; Yacomareenya produces Neenum; Neenum's daughter is Neomarum; Neomarum has a daughter Noolum. This series also repeats itself for ever and may be distinguished as "Cycle Y."

It is evident therefore, that the women of a cycle or phratry pass successively through each of the four sections of which it is composed in as many generations, the same section name reappearing in the fifth epoch. If the totems were transmitted directly through the women, they would also remain constantly in the same cycle, and reappear in the same rotation as the women. Comprehensive investigations respecting the descent of the totems in the Wombaia tribe and its congeners, however show that the totems do not follow such a law, because the women of a cycle are not coincident with the intermarrying sections shown in Table II.

In Table I. the husbands, wives, sons and daughters are given on the same line across the page. For example, Choolum marries Ningulum, Jamerum marries Palyareenya and so on for all the others. But extended enquiries reveal the fact that a man of any stated section has potential

marital rights over three additional sections of women. Choolum's wife may be either a Ningulum as in Table I., or a Nooralum, or a Neenum, or a Noolum. That is, he can espouse a Ningulum or a Nooralum from phratry A; or a Noolum or a Neenum from phratry B. Consequently Table I. does not represent such a bisection of the community into two intermarrying moieties as would constitute exogamy. This at once raises the crucial question, Is there any real exogamy in the Wombaia or kindred tribes?

Further study of the actual intermarriages demonstrates that the four sections of women into which Choolum can marry are equally liable to be claimed as wives, though in a different order, by three other sections of men, viz.:—Cheenum, Chooralum and Chingulum. I will now submit another table, showing a category of four sections of women from among whom four specific sections of men must obtain their wives in accordance with aboriginal custom.

TABLE II.

| Phratry. | Husband. | Wife. | Progeny. |
|---|---|---|---|
| A | Choolum | Ningulum | The children of each individual woman are the same as in Table I., quite irrespectively of the name of the husband. |
| | Cheenum | Nooralum | |
| | Chooralum | Neenum | |
| | Chingulum | Noolum | |
| B | Jamerum | Palyareenya | |
| | Yacomary | Bungareenya | |
| | Bungarin | Yacomareenya | |
| | Palyarin | Neomarum | |

In consequence of any specific woman in the "Wife" column of Table II. being eligible for marriage with any one of four different sections of men in the "Husband" column, it becomes evident that such a woman's child's father might have any one of four section names, depending upon which husband she had married. Let us take Palyarin the first name in the "Son" column of Table I. as an example. If his mother, Ningulum, had married

Choolum, he will be Palyarin's direct, or "First" father. If she had mated with Cheenum, he would be the alternative, or "Second" father of Palyarin. If she had taken Chingulum as her husband, he would be the "Third" father. And if Ningulum had married Chooralum, then he would be Palyarin's "Fourth" father. That is to say, it makes no difference to Ningulum which of the four men she marries—her son will be Palyarin just the same. We observe that two of the four possible husbands of Ningulum come from phratry A and two from phratry B in Table I., which is an additional argument against exogamy.

In all cases the section name of the progeny is irrevocably determined through the mother. If Choolum marries Ningulum his children are Palyarin and Palyareenya; if he takes a Nooralum they are Bungarin and Bungareenya; if he chooses a Neenum they are Jamerum and Neomarum; and if he be allotted a Noolum they will be Yacomary and Yacomareenya. See Table I., which exhibits the children of any and every section of women.

Let us provisionally call the category or set of four women noted under the head "Wife" in the upper half of Table II. a phratry. Then it becomes manifest that the men and women of the *same* phratry intermarry among themselves, and consequently there is no exogamy of the sections.[1]

Again adopting the phratries as set down in Table II., there could not be any regular succession of the totems, either patriarchal or matriarchal. For example, if we postulate that descent is reckoned through the men, and that the eaglehawk is the totem of Choolum, who has several brothers who all inherit the same animal from their common father. By working out genealogies it can be

[1] Tables II. and III. are introduced merely for illustration. Table I., shows the correct arrangement of the sections and phratries.

demonstrated that this totem would not only be liable to be disseminated through the children of any or all the sections in phratry A, Table II., but in a few generations it could be similarly distributed to the children of some or all the sections in phratry B. Therefore there could not be any totemic partition of the tribe into two phratries or moieties; or in other words there would be no exogamy.

Furthermore, if we assume that succession of the totems is through the women and work out an example from Table II., we shall discover that half the women of each phratry would respectively confer their totems on half the women of the other. All the totems would thus be scattered through both the phratries,[1] rendering exogamy impossible. It appears then that whether we endeavour to trace the totems according to the fathers or the mothers, the result is practically the same.

The section names of the men follow a different order to those of the women—they see-saw from father to son in alternate generations. Thus Choolum has a son Palyarin, and in the next generation Palyarin has a son Choolum, and so on for all the other sections. In 1900 I published a table suggesting how descent might be counted through the men, of which the following is a copy.

TABLE III.

| Phatry. | Husband. | Wife. | Son. | Daughter. |
|---|---|---|---|---|
| A | Choolum | Ningulum | Palyarin | Palyareenya |
| | Palyarin | Neomarum | Choolum | Noolum |
| | Cheenum | Nooralum | Bungarin | Bungareenya |
| | Bungarin | Yacomareenya | Chenum | Neenum |
| B | Jamerum | Palyareenya | Chooralum | Nooralum |
| | Chooralum | Neenum | Jamerum | Neomarum |
| | Yacomary | Bungareenya | Chingulum | Ningulum |
| | Chingulum | Noolum | Yacomary | Yacomareenya |

[1] This statement applies only to Table II. If the totems descended through the women as arranged in Table I., they would remain constantly in the same cycle, similarly to the totems of the Wongaibon and Barkunjee, reported in later pages.

In the table I placed Choolum, Palyarin, Cheenum and Bungerin together, to constitute phratry A, and the remaining four sections formed phratry B. My reason for placing these four sections together was because they represented fathers and sons. Choolum is the "direct" father of Palyarin and the "alternative" father of Bungarin. Palyarin is the "direct" father of Choolum and the "alternative" father of Cheenum.

It seemed to me that if there was any possibility of the succession of the totems being through the men, this would be the best way of ascertaining it. But as soon as I made the discovery that Choolum, as well as all the other sections in the table, had the further right of marrying a third or a fourth section, (Table II.), it became apparent that two of the potential wives of a man of any given section would come from phratry A and the other two from phratry B. No matter in what order these four names may be arranged, it does not alter the fact that they cannot possibly form an exogamous moiety of the tribe.

The foregoing pages illustrate how all the different sections intermarry and are perpetuated. Upon this foundation the actual marriages of specific individuals are regulated by a system of betrothals, which are made after a child is born, and sometimes before that event. The selection of a wife or husband is determined through the grand-parents of the parties to the matrimonial alliance. The following short genealogical tables will elucidate the letterpress:

TABLE IV.

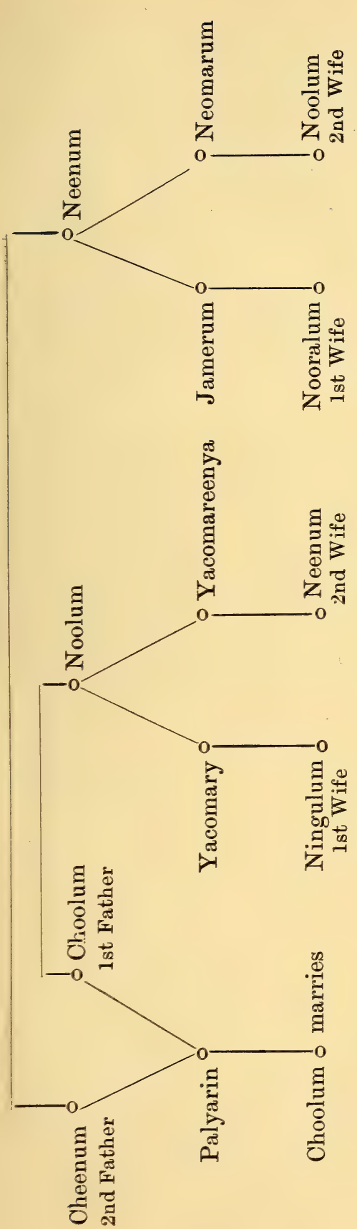
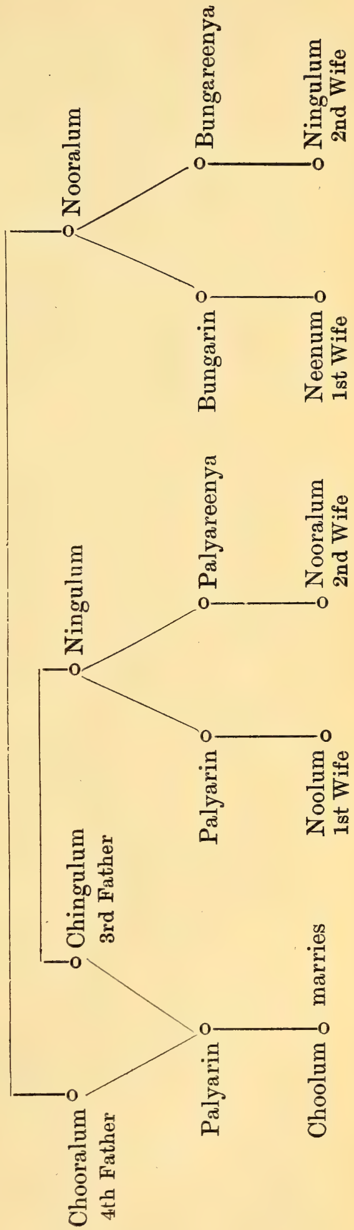



TABLE V.



It was stated in an earlier page that although a man can have but one actual father, yet this father's section name depends upon whom the man's mother had married. A man of any given section may therefore have four different nominal grandfathers. And upon tracing out the genealogies of several families by the continued assistance of trustworthy correspondents who have resided in that district for years, I find that there are, so to speak, four sorts of men in each section—for example, there are four Choolums of different lineage, whom we shall distinguish as Nos. 1, 2, 3, and 4.

Looking at Table IV., and in the left side of it, we see that the father of Choolum No. 1 is Palyarin and that Palyarin's direct or "1st Father" is Choolum. Then Choolum No. 1 marries his father's direct or "1st Father's" sister's son's daughter Ningulum as his "1st Wife" already described in Table II. Or he marries his father's "1st Father's" sister's daughter's daughter Neenum as his "2nd Wife."

If we take Choolum No. 2, with another pedigree, still looking at Table IV., then he espouses his father's alternative or "2nd Father's" sister's son's daughter Nooralum as his "1st Wife." Or he takes his father's "2nd Father's" sister's daughter's daughter Noolum as his "2nd Wife."

Perusal of Table V., introduces Choolum No. 3, whose father's "3rd Father" is Chingulum, and also Choolum No. 4, whose father's "4th Father" is Chooralum, but it is expected that the table will speak for itself. It is manifest, therefore, that whatever one of the four specific women which a man of a given section is allowed to take as a wife possesses practically the same relationship to him, although through different channels.

On account of the section name descending through the women, it would have been quite as well, or perhaps better, to have traced Choolum's pedigree back through his mother's father, instead of through his father's father. Looking at Table I., we see that Neomarum is the mother of Choolum. Examination of that table will show us that Neomarum's "1st father" is Chooralum; her "2nd father" is Chingulum; her "3rd father" is Choolum; and her "4th father" is Cheenum. Then Choolum No. 1 would marry his mother's "1st father's" sister's daughter's daughter, Ningulum, as his "1st wife." Or he marries his mother's "1st father's" sister's son's daughter, Neenum, as his "2nd wife" and so on.

According to this arrangement, the normal marriages would be those of a man's daughter's child with his sister's daughter's child. Tables IV. and V. could be easily amended, by a little transposition, for the purpose of showing all the details in full. Among the Wongaibon and Barkunjee tribes, described a few pages onward, if we follow a man's genealogy through his mother, the normal marriage would be that of a man's daughter's child with his sister's daughter's child, and so on, the same as in the Wombaia tribe.

I have placed Choolum and Cheenum together as grandfathers in Table IV. My correspondents in the Northern Territory several years ago informed me that these two sections of men are very friendly amongst themselves, and frequently marry into the same two sections of women, in inverse order.[1] Moreover, referring back to Table I., we observe that Choolum and Cheenum take their direct or tabular wives from the same cycle of women. For similar reasons I have placed Chingulum and Chooralum together as grandfathers in Table V.

[1] This Journal, xxxiv., pp. 123, 129.

According to Table IV., Choolum No. 1 marries a Ningulum or a Neenum, who is represented as his 1st or 2nd wife. Choolum No. 2 is allotted a Nooralum or a Noolum in the same way. Choolum No. 3 (Table V.) espouses a Noolum or a Nooralum. Choolum No. 4 mates with a Neenum or a Ningulum. But there are customary extensions of these rules by means of which any Choolum who is a paternal or maternal grandson of either Choolum or Cheenum (Table IV.) can marry into any one of the four sections mentioned; and any Choolum who is a paternal or maternal grandson of either Chingulum or Chooralum (Table V.) can espouse any one of the same four sections of women.

The sequence in which these marriages take place is as follows:—Choolum No. 1 marries Ningulum, Neenum, Nooralum or Noolum. Choolum No. 2 takes Nooralum, Noolum, Ningulum or Neenum. Choolum No. 3 mates with Noolum, Nooralum, Neenum or Ningulum. Choolum No. 4 espouses Neenum, Ningulum, Noolum or Nooralum.

Study of Tables IV. and V. shows that Choolum No. 1 marries as his first wife a woman belonging to "Cycle Z" mentioned in the explanation of Table I. For his second wife he takes a woman from "Cycle Y." The Choolums Nos. 2, 3 and 4 obtain a wife for each cycle in the same manner. But if Choolum No. 1, or any of the Choolums mentioned, has potential marital rights over the women of all the four sections, as stated in last paragraph, then he might be permitted to vary the order of succession of his possible wives, and select a Ningulum as his "1st" or a Nooralum as his "2nd" wife, and in that case both the women would belong to the same cycle.

When my correspondents in compliance with my request prepared lists of the section names of certain well-known men who were actually married to more than one wife among the Wombaia and other tribes, it became apparent

that the most general custom was to take a "1st" and "2nd" wife from the *same* cycle of women. Instances of polygamy were found, however, in which the wives were from both cycles in accordance with Tables IV. and V.

Although there are four sorts of men in each section—four Choolums for example in that division—they practically resolve themselves into two, namely, those who marry women of the Z Cycle and those who obtain their wives from the Y Cycle (see Table I.). This really amounts to a partition of the Choolum section into two parts instead of four. Again looking at Table I., we observe that Choolum and Cheenum take two of their possible wives, who are at the same time the two most usual, from Cycle Z and the other two from Cycle Y. The remaining two sections of men, Jamerum and Yacomary, do the same. As regards the succession of the totems, this matter has been concisely described in my paper.[1] In that article I stated that "the partition of a tribe into two exogamous portions would be impossible."

Before quitting the eight-section system, it will be well to state that everything which has been said in the preceding pages against the existence of exogamy, refers equally to the Binbingha, Chingalee, Yungmunni, Warramonga, and Arunta tribes. What I have stated is likewise applicable to all the native tribes on the Victoria river, as well as to those on Hall's Creek and surrounding country in the State of Western Australia. There is an indubitable absence of exogamy throughout them all.

## Sociology of the Wongaibon Tribes.

The territory of the Wongaibon extends approximately from about Booligal up the Lachlan river to Euabalong, thence to Nyngan, Cobar, Paddington and Ivanhoe. Their

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[1] "Ethnological Notes on the Aboriginal Tribes of Queensland," *Proc. Roy. Geog. Soc.* (Queensland), xx., pp. 72 – 75.

language and initiation ceremonies have already been published by me.[1] Beyond a few fragmentary and inaccurate outlines, practically nothing has hitherto been published respecting the sociology of the Wongaibon community. Several of their subdivisions have never been even mentioned by any author until now. A table will be used to illustrate the letterpress.

TABLE VI.

| Phratry. | Husband. | Wife. | Son. | Daughter. |
|---|---|---|---|---|
| Ngūmbūn | Murri | Ippatha | Kumbo | Butha |
| | Kubbi | Butha | Ippai | Ippatha |
| Ngurrawan | Ippai | Matha | Kubbi | Kubbitha |
| | Kumbo | Kubbitha | Murri | Matha |

Besides the divisions shown in the table, every individual, male and female alike, claims some animal or plant or other object as his totem. Each phratry and the sections of which it is composed possesses a further distinctive division into Guaigullimba and Guaimundhan, signifying swift blood and sluggish blood respectively. These may be called "blood" divisions or castes. There is still another repartition of the community, which can be distinguished as "shade" divisions. These divisions are in reality an extension of the "blood" castes, and regulate the camping places of the people under the shades of large trees.

Intermarriages are regulated as follows :—A man of the Ngurrawan phratry and Ippai section marries a Ngūmbūn woman of the Matha section. This is the normal rule of marriage. In such a case, a man's son's child marries his sister's son's child. But it is quite lawful for Ippai to espouse an Ippatha. which represents the marriage of a man's son's child with his sister's daughter's child. These two alliances are the equivalents of Choolum marrying Ningulum and Noolum respectively in Table IV.

[1] This Journal, xxxvi., pp. 147 – 154; *Proc. Roy. Geog. Soc.* (Queensland), xi., pp. 167 – 169.

Another variation in the intermarriages of the sections allows the Ippai of our example to wed a Kubbitha or a Butha, corresponding to the marriage of Choolum with Nooralum and Neenum in the Wombaia tribe (Table IV.). In other words, a man of any given section can marry into one or other of the three remaining divisions or else into his own. It is needless to add that these facts altogether disprove the existence of exogamy in the Wongaibon tribe.

Reference to Table VI. shows us that the children follow the phratry or cycle of their mother, but they do not bear the name of her section, but that of the supplementary one, because the women of a cycle reproduce each other in continuous alternation. That is, the section name is invariably determined through the women. The totems remain constantly in the same cycle as the women and are accordingly transmitted from the mother to her progeny. Although the totems, as well as the sections and phratries, are perpetuated through the women, this does not constitute exogamy. We have already shown that an Ippai, for example, can marry into either cycle of women, and consequently a totem of either cycle.

Again, a Guaigullimba mother produces Guaigullimba children, who also take their mother's "shade." The castes of "blood" and "shade" are not necessarily coincident with the other divisions, but apply to any section according to pedigree. In short, they divide the people of every section into two sorts, and are used in tracing out the betrothals and who shall marry whom. There are for example, two sorts of Ippais. If the one who married Matha as already stated, was a Guaigullimba the Ippai who espoused Ippatha would be a Guaimundhun, analogously to the subdivisions of the Choolum section in the Wombaia tribe. An Ippai who could take a Kubbitha for a wife would be a different "blood" from the one who could marry a Butha.

## Sociology of the Barkunjee Tribes.

In 1898 I wrote a paper[1] describing the initiation ceremonies of the Barkunjee and their congeners, accompanied by a map exhibiting the boundaries of the extensive region which they occupied in the western portion of New South Wales. I now desire to very briefly refer to their sociology.

The people of these tribes are segregated into two primary divisions, of which the intermarrying laws and the descent of the progeny will be easily understood from the accompanying table and explanatory letterpress.

TABLE VII.

| Phratry. | Husband. | Wife. | Son. | Daughter. |
|---|---|---|---|---|
| A | Mukkungurra | Kilpungurraga | Kilpungurra | Kilpungurraga |
| B | Kilpungurra | Mukkungurraga | Mukkungurra | Mukkungurraga |

The feminine form of the divisions is distinguished from the masculine by the suffix *ga*. A Mukkungurra usually marries a Kilpungurraga, as in the above table and the resulting offspring are Kilpungurra and Kilpungurraga. In such case a man's son's child marries a sister's son's child. But if a Mukkungurra takes a Mukkungurraga as his conjugal mate, that represents the marriage of a man's son's child with a sister's daughter's child. This conclusively demonstrates that there is no exogamy among the Barkunjee people.

Every man woman and child bears the name of some animal, plant or natural object as his or her totem, which is in all cases inherited from the female parent. There is a further partition of the people into Muggulu and Ngipuru, meaning sluggish blood and swift blood. A Muggula may belong to either phratry and a Ngipuru individual has the same scope. That is, these "blood" divisions, like the totems, are dispersed indiscriminately throughout the tribal territory.

[1] This Journal, xxxii., pp. 233 – 250.

A man of the Muggulu blood and the Butt shade usually marries a Ngipuru woman of the Branch shade, but this is subject to some irregularities. In regard to the offspring, a Muggulu mother produces Muggulu children, who take their mother's Butt shade; a Ngipuru woman produces Ngipuru children, belonging to the Branch shade. Moreover, the children take the mother's totem.

Intermarriages of individuals of the same totem are forbidden. When a Kilpungurra marries a Mukkungurraga there is no risk of conflict with the totemic regulations. If a Kilpungurra man, however, could mate with any Kilpungurraga, it would be possible for the parties to belong to the same totem; but a Kilpungurraga of the proper lineage could not possibly be of the same "blood caste" as the man.

As an evidence of the importance attached to the "blood" divisions, they are brought into prominence at the scarring of the bodies of the young men during the initiation ceremonies. A Muggulu youth has his shoulders and chest marked with shorter scars, whilst a Ngipuru youth has longer scars, to distinguish one from the other. See my "Mumbirbirri or Scarring the Body."[1]

My remarks on the absence of exogamy among the Barkunjee, apply with equal cogency to all the native tribes who occupied the whole of the western half of Victoria, where the divisions are called Gurogity and Gamaty. Last year I reported certain facts respecting the intermarriages of these divisions, which render exogamy absolutely impossible.[2]

### Conclusion.

I have elsewhere stated that whether there are two, or four, or eight divisions of the entire community, the principles which regulate marriage and descent among the

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[1] This Journal, XXXVIII, pp. 262, *seq.* [2] *Loc. cit.*, pp. 290 and 295.

divisions are identical in them all.[1] I shall endeavour to briefly place an outline of this identity before the reader.

We have seen that the Barkunjee people possess only two divisions or phratries, Table VII. A man of phratry A marries a woman of phratry B. It is also apparent that the men of phratry A, for example, can take their wives from either phratry. This amounts to the statement that the aggregate of men in phratry A can marry all the women in the community.

Next, taking the Wongaibon tribe, Table VI., we find that the two sections, Murri and Kubbi, if taken together, are equal to Mukkungurra of the Barkunjee, and Ippai and Kumbo together represent Kilpungurra. Murri and Kubbi taken jointly marry Butha and Ippatha taken jointly in one phratry. But Murri and Kubbi can jointly marry Matha and Kubbitha taken jointly in the other phratry, which is equal to Mukkungurra espousing Mukkungurraga in the Barkunjee. A little consideration shows us that the Murris and Kubbis taken collectively can marry into the whole four sections of the community.

We now come to the Wombaia divisions, Table I., which on account of their number will occupy a little more space to describe. Choolum and Cheenum, taken together as one person, represent Murri. They marry Ningulum and Nooralum, who together represent Butha, the wife of Murri. Jamerum and Yacomary together represent Kubbi.[2] They marry Palyareenya and Bungareenya, the daughters of Ningulum and Nooralum, who represent Ippatha, the daughter of Butha and wife of Kubbi. That is, Choolum, Cheenum, Jamerum and Yacomary, collectively, marry all the women in phratry A of Table I., the same as Murri

[1] *Bull. Soc. d' Anthrop. de Paris,* tome II., Serie V., (1901) p. 415.

[2] These equivalents are only assumed, for the sake of comparison.

and Kubbi marry all the women of a phratry in the Wongaibon tribe, Table VI.

But Choolum and Cheenum, the equivalent of Murri, can also marry Noolum and Neenum the equivalent of Matha. Jamerum and Yacomary, the equivalent of Kubbi, can marry Yacomareenya and Neomarum the equivalent of Kubbitha. That is, Choolum, Cheenum, Jamerum and Yacomary, collectively, can marry all the women in phratry B, the same as Murri and Kubbi can marry all the women of the other phratry in the Wongaibon. Examination of Table I. will show that Choolum, Cheenum, Jamerum and Yacomary, taken in the aggregate, can not only marry all the women in either phratry, but they can intermarry with the whole eight sections of the Wombaia community, Table I., the same as Murri and Kubbi can marry into all the four sections of the Wongaibon.

The four preceding paragraphs may be recapitulated as follows: In the Barkunjee community, a single division, Mukkungurra, represents phratry A. In the Wongaibon tribe, two divisions, Murri and Kubbi constitute phratry A. Among the Wombaia people the four divisions Choolum, Cheenum, Jamerum and Yacomary form phratry A. My examples have all been from one phratry because the same rules apply to both. In all these tribes the women are divided into two primary cycles, groups, phratries, moieties, classes, or whatever name we may employ to distinguish the divisions. It is also manifest that the name of the cycle or phratry to which the progeny belongs is in all cases established through the women, altogether irrespectively of the divisional name of the father.

Perhaps I should state here that in 1898 I described the sociology of the Dippil and other tribes[1] spread over the region lying between the northern boundary of New South

[1] *Proc. Amer. Philos. Soc.*, Phila., XXXVII., pp. 327 – 336, with maps.

Wales and the 19th parallel of south latitude which represents more than half of Queensland, which I delineated on a map. In that article I stated that a man of the Barrang section could marry a Barrang woman, a fact which disproves the existence of exogamy in that part of Queensland. In treating the tribes of Cape York Peninsula in 1900 I gave examples of a man marrying into both phratries.[1] Since that time in dealing with the sociology of the Murawarri, Baddyeri and Inchalanchee tribes, reaching from the New South Wales boundary to the Gulf of Carpentaria, I reported some intermarrying laws which are altogether opposed to exogamy.

All the particulars contained in this treatise respecting the Wongaibon and Barkunjee tribes have been collected by myself from the natives personally. My information regarding the Wombaia tribe has been obtained with the aid of trustworthy correspondents who have resided in that part of the country for many years. I have adopted none of the opinions nor followed any of the methods of other Australian authors, but have struck out on my own lines. The present article is necessarily very brief, but it is believed that it will shed much new light on the social organisation of the aboriginal tribes of Central Australia, New South Wales, Victoria and Queensland, and enable investigators to make a fresh start.

Spencer and Gillen,[2] have given a table of the eight divisions of the Umbaia (Wombaia) tribe, which cannot possibly represent any practical partition of the sections into cycles, phratries, or moieties. They erroneously state that descent of the sections is through the men, and they are altogether mistaken in asserting that the community is divided into "two exogamous groups."

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[1] This Journal, xxxiv., p. 132.

[2] "Northern Tribes of Central Australia," (London, 1904), pp. 70 and 100.

Dr. A. W. Howitt[1] states that "all Australian tribes are divided into two moieties, each of which is forbidden to marry within itself." He is also in error in speaking of "the segmentation of the community into two exogamous moieties."

Having studied the question of Australian sociology for many years, I am forced to the conclusion that neither promiscuous intercourse of the sexes nor what has been called "group marriage" has ever existed among the social institutions of the aborigines of Australia.[2] I am equally convinced that the divisions into cycles, phratries and sections have not been deliberately formulated with intent to prevent consanguineous marriages and incest, but have been developed in accordance with surrounding circumstances and conditions of life. This important division of the subject will receive full attention in a future treatise.

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[1] "Native Tribes of South-east Australia," (London, 1904) pp. 88 and 284.

[2] "Les Indigènes d'Australie," *L' Anthropologie,* (Paris, 1902) XIII., p. 240.

# ON AN UNDESCRIBED SPECIES OF LEPTOSPERMUM AND ITS ESSENTIAL OIL.

By RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

[With Plate II.]

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

## THE LEMON SCENTED LEPTOSPERMUM.

*Leptospermum Liversidgei*, sp. nov.

A shrub 6 to 12 feet high, glabrous, with erect numerous branches and branchlets, the lower branchlets *being quite filiform* and having persistent leaves only on the upper part. Leaves flat, concave and slightly curved, 2 to 3 lines long, very numerous and imbricate, sessile or with a very short petiole, mostly lanceolate but also ovate, rather thin, 1 to 3 nerved but not always clearly shown. Oil glands numerous and distinctly marked. Flowers solitary, axilliary on the branchlets, on a short pedicel, measuring about 6 to 8 lines in diameter when expanded. Calyx quite glabrous, broadly campanulate, lobes rounded, as long as the tube, thickened in the middle. Petals orbicular, spreading, much larger than the calyx lobes, about 2 lines in diameter, faintly veined. Ovary five-celled, flat on the top with a slight depression round the base of the pistil and a circular ridge near the free edge of the calyx. Capsule domed above the distinct flange of the calyx, 2 to 3 lines in diameter.

Habitat—Ballina (D. W. Munro), Byron Bay (J. H. Maiden and J. L. Boorman), Port Macquarie (all New South Wales localities).

*L. Liversidgei*, apart from its chemical constituents, has marked points of difference from cognate species. It was at first thought to be one of the many varieties of *L. flavescens* on account of its glabrous calyx, a common feature of all the species placed systematically with that "tea" tree, but the shape and disposition of the leaves, branchlets, size of the flower and chemical constituents of the oil are facts that we considered to be of sufficient importance to justify its differentiation from that species. Typical *L. flavescens* has an extensive range in the coast districts of all the eastern States of the continent, and exhibits a marked constancy of specific characters throughout its distribution especially in the shape of the leaves, which as stated by Smith in his original description,[1] "are linear, lanceolate, obtuse and nerveless,"—a description that does not apply to the leaves of this species, which apart from the other features quoted, may be said to be imbricate whilst those of Smith's plant are loose and spreading. Bentham (B.Fl. iii., p. 104-5) gives a number of species and varieties under *L. flavescens*, classifying them as:—

(a.) *commune*—This includes Smith's specimen (regarded as type) and one or two other species of different authorities.

(b.) *obovatum*—With this variety are synonymised Sweet's *L. obovatum* and Miquel's *L. micromyrtus*. This is a plant more nearly approaching var. *microphyllum*, having divaricate branches but distinct ovate leaves which are flat and not recurved, and are much larger than those of that var. or this new species.

(c.) *grandiflorum*—Under this are placed *L. grandiflorum*, Lodd., *L. virgatum*, Schau., *L. nobile*, F.v.M. The leaves, flowers and fruits of this var. are longer and finer than those of this new species and not so numerous and differently shaped.

[1] *Trans. Linn. Soc.*, III., p. 262.

(d.) *microphyllum*—It was at first thought that *L. Liversidgei* might be this variety, and was so named by us at first, but a further investigation showed this determination to be wrong. This variety is a robust shrub with stout, divaricate or dichotomous branchlets with leaves drying a light grey colour and the whole plant resembling somewhat a small variety of *L. lævigatum* with scattered leaves, a marked contrast to the erect branches with very numerous very fine slender filiform branchlets of this new species which has also less numerous, more distant and differently shaped leaves.

(e) *minutifolium*, of F.v.M.—This is altogether a different form from this new one, having distinctly channelled recurved leaves, smaller and differently shaped to those of *L. Liversidgei.* It has also stouter branchlets and never the slender filiform ones of the latter species, and its leaves are distinctly 3-nerved, whilst the flowers show good characteristic differences, are much smaller, and the petals being more deciduous.

*L. scoparium*, Forst. and *L. arachnoideum*, Sm., have each a glabrous calyx, and that is their only resemblance to this species.

## Essential Oil.

The lemon odour which this plant gave when the leaves were crushed, was considered to be an indication of the possible presence of citral, and as the results promised to be of an interesting nature, a quantity of material was obtained for distillation. The material was collected several days before it reached the Museum, and the leaves had, by that time, become so loosely attached to the stem that they easily fell off when the twigs were shaken. The leaves of this plant are very small, and as they so readily fall off it would be desirable to distil the plant soon after collecting. The twigs and woody portion were present in larger amount

than would be necessary for commercial distillation, so that the yield of oil as here given, is perhaps a little less than would be obtained commercially, particularly if care were taken in the collection of the material.

The amount of oil obtained from 373 pounds of leaves and branchlets was 13½ ounces, equal to 0·227%. The crude oil was somewhat mobile and had a marked secondary odour of citral; it was reddish-brown in colour, but this, being due to the mode of distillation, was accidental. The red colour was entirely removed by agitating the oil with a very dilute solution of aqueous potash or soda; after this treatment the oil was of a light lemon tint.

The principal constituents in the oil were, (1) the aldehyde citral, (2) an alcohol considered to be geraniol, (3) an acetic acid ester considered to be geranyl-acetate, (4) the terpene pinene which was dextrorotatory, and (5) a sesquiterpene, which is probably the constituent which gives the lævo-rotation to the higher boiling portion. Limonene could not be detected by any method, and was, therefore, absent; nor was phellandrene present. The whole of the aldehyde appears to be citral, as proof of the presence of any other aldehyde could not be obtained, and two determinations by Flatau and Labbe's method failed to give any indication for citronellal. The physical determinations seem also to indicate that citral is alone present. The secondary odour of the oil, from which the aldehydes had been removed, strongly resembled that of geraniol. The oils of the Leptospermums do not appear to have been chemically investigated, so that the occurrence of citral in the oil of *Leptospermum Liversidgei* is of some scientific interest.

## EXPERIMENTAL.

The crude oil was insoluble in 10 volumes 70% alcohol (by weight) but was soluble in 1 volume 80% alcohol. The rotation in 100 mm. tube was $a_D + 9{\cdot}2^\circ$. The refractive

index at 16° C. was 1·4903. The specific gravity at 15° C. was 0·8895. On a first rectification three main divisions were detected, but owing to the presence of such a large proportion of high boiling constituents the lower boiling portion was not readily separated. Below 170° C. 20% distilled; the specific gravity at 15° C. of this fraction was 0·8624, the refractive index 1·4774 at 16° C., and the rotation in 100 mm. tube $a_D$ + 32·5°. Between 195–225° C. 30% distilled; the rotation of this fraction was + 5·7°; the specific gravity 0·8892, and the refractive index 1·4892. Between 225–235° C. 20% distilled, this fraction was lævorotatory, the rotation being –1·1°; the specific gravity was 0·9048, and the refractive index 1·4945. Between 235–273° C. 12% distilled, which consisted largely of a sesquiterpene, the refractive index of this fraction was 1·5052 and the specific gravity 0·9024; the rotation could not be well taken, but it was lævorotatory. The indications thus pointed to the presence of pinene, of a large proportion of alcohols or aldehydes, of a sesquiterpene and perhaps esters.

The first fraction was again distilled, and the portion boiling at 155–157° C. was collected apart. This was shown to be dextrorotatory pinene. The specific gravity when cooled to 15° C. was 0·8601; the refractive index at 20° C. was 1·4706, and the rotation $a_D$ + 35·5°. The nitrosochloride was also prepared and this melted at near 103° C. When the oil distilling between 170–195° C. was rectified pinene was again obtained. It is thus assumed that about 25% of the oil was pinene. When the oil was treated with twice the volume of a 30% solution of sodium bisulphite a solid mass soon formed, the aldehydic portion readily dissolved when heated in the water bath. Two closely agreeing determinations by this method, in the ordinary way, gave a mean yield of 35% of aldehydes. The aldehydic

constituents were also removed from a larger quantity of oil prepared for the other determinations, and the separated oil carefully collected and weighed; 40 grams of oil gave 25·9 grams of non-aldehydic constituents, equal to 35·25% of aldehydes. The barium salt of the aldehydic bisulphite compound was prepared, and the aldehyde when separated from the filtrate by the addition of soda, extracted by ether and steam distilled, was shown to be citral. Its odour indicated that aldehyde, its specific gravity at 21° C. was 0·8929 and it had a refractive index 1·4913 at 20° C., it was also inactive to light, and the naphthocinchoninic acid, prepared by Doebner's reaction, melted at 199° C. The very small amount of aldehyde (about one per cent.) obtained from the barium precipitate in the usual way, gave no indication for citronellal, but consisted apparently of partly polymerised citral as indicated by the odour and by the refractive index.

The citral prepared from the crystalline bisulphite compound by purifying the crystals with ether-alcohol, decomposing with sodium carbonate and steam distilling, gave at 20° C. a refractive index 1·4913 and specific gravity 0·8937, indicating that citral is the only aldehyde present.

The non-aldehydic portion of the oil had a specific gravity 0·8866 at 20° C.; rotation + 13·4°; refractive index 1·4855 at 22° C. The index of the original oil determined at the same time and under identical conditions was 1·4873, so that the index of the aldehyde was higher than that figure. The ester determination was made on the non-aldehydic portion of the oil, the saponification number was 23·5 equal, to 8·225% of ester as geranyl-acetate. The aldehyde being 35%, this gives 5·346% of ester in the original oil. A determination for ester in the crude oil gave 5·54%. A portion of the non-aldehydic oil was esterised in the usual way, and this gave a saponification number 73·63, which repre-

sented 14·98% of free alcohol, or 9·74% of geraniol in the original oil.

The oil of *Leptospermum Liversidgei* may be stated to have approximately the following composition :—

| | | |
|---|---|---|
| Citral ... ... ... ... | 35·00 | per cent. |
| Geranyl-acetate ... ... ... | 5·35 | ,, |
| Free Geraniol ... ... ... | 9·74 | ,, |
| Dextro-pinene ... ... ... | 25·00 | ,, |
| Sesquiterpene and undetermined | 24·91 | ,, |
| | 100·00 | |

This species is dedicated to Prof. A. Liversidge, M.A., LL.D., F.R.S., of the Sydney University, and twice President of our Society, as a slight recognition of his efforts in the furtherance of industrial science in Australia. It was due largely to his efforts that the Technological Museum, Sydney, was established, and as one of the original Committee of Management he was ever enthusiastic in its development, and is always ready to place his mature experience at the disposal of its officers.

We have to acknowledge our indebtedness to Mr. J. H. Maiden, F.L.S., for his kindness in allowing us the use of the Leptospermums of the National Herbarium for comparative purposes, and also to Mr. E. G. Duffus, Secretary for Agriculture, Melbourne, and Mr. J. R. Tovey, the officer in charge of the Victorian Herbarium, for similar favours.

## Explanation of Plate

1. Flowering twig. 2. Bud. 3. Bud partially expanded. 4. Expanded flower. 5. Horizontal section of flower. 6. Spray with fruits. (2, 3, 4, 5, enlarged.)

# NOTE ON A HOLLOW LIGHTNING CONDUCTOR CRUSHED BY THE DISCHARGE.

By J. A. POLLOCK, Professor of Physics,
and
S. H. BARRACLOUGH, Lecturer in Mechanical Engineering
in the University of Sydney.

[With Plate III.]

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

THE piece of lightning conductor to which this note refers was submitted to us by Mr. G. H. Clark of Sydney. It consists of a tube originally cylindrical, 17·5 cms. long, the outer diameter being 1·8 cms., made of copper 0·1 cm. thick with a lap joint 0·4 cm. wide where the thickness is 0·2 cm. The piece was the upper portion of a pipe 135 cms. long, connecting the finial with a copper band running down a chimney. The specimen, photographs of which are given in *Plate* III., is crushed in a symmetrical manner and shews the characteristic appearance of a tube which has collapsed under external pressure.

The crushing is probably due to the electrodynamic action of the current. On this assumption if the stress at which the tube gave way was known, one could obtain some knowledge of the current during the discharge. For the tube under consideration, a calculation, particulars of which are given below, shows that the mechanical effect at any moment due to the current measured in ampères is equivalent to an excess of hydrostatic pressure on the outside of the tube of $n$ atmospheres, where

$$I = 22000 \sqrt{n}$$

$I_0$ being the total current in the conductor at the given moment.

For reasons given later, we believe that the material of the tube was probably plastic at the time of collapse, owing to the heat developed by the discharge. If this is so, the pressure required to produce the observed folding at any assumed temperature, cannot be calculated; the theory applicable to such a case and the data of the mechanical properties of copper at the high temperatures here contemplated are alike wanting. Possibly the material was in such a state that the tube gave way under forces equivalent to an excess of pressure outside of the order of not more than an atmosphere; this would indicate a current of about 20,000 ampères, neglecting any consideration of the oscillatory character of the discharge.

On the other hand if the material was not plastic, assuming a temperature as low as 500° C. at the time of crushing we estimate that the collapsing pressure would be of the order of 400 lbs. per sq. inch; forces equivalent to such a pressure would be produced by a current of about 100,000 ampères.

To illustrate the action of the current suggested above, extremely thin tubes were made by depositing copper electrolytically on silvered glass rods. The ends of the tubes were thickened and the glass rods afterwards removed. On passing a current along the tubes, at a red heat they showed definite signs of collapse though not the characteristic folding exhibited by the piece of lightning conductor. In the Report of the Lightning Rod Conference (Spon 1882) on p. 214, a detailed account is given of a hollow conductor which had been struck by lightning, but no mention is made of any appearance of collapse. The tube was however stiffer than the one submitted to us, the external diameter being 1·27 cms. as against 1·8 cm. and the smallest thickness 0·16 cms. as against 0·10 cm.

## Description of the Conductor.

Fig. 1 is a sketch to scale of the upper portion of the lightning conductor, the parts drawn in continuous lines shewing the pieces which have been preserved. *a b* represents the pipe, whose dimensions have been already given. At *a* and *b* the pipe was sweated on to solid rods, the upper one being attached to the ball and the lower one to a right angled piece to which the main conductor was attached. The folding is most pronounced at *b* just below the end of the solid rod; it is not quite symmetrical as the pipe is stiffer at the lap joint. Folding is also shown at *a* just above the end of the solid rod; at this point the pipe was fused. The greater portion of the pipe from *c* to *a* was unaltered in shape, its section remaining circular. After the fusion at *a* the lower part of the conductor fell away but the pipe remained vertical throughout its length, attached to the chimney by the two holdfasts shown. Photographs of the part *b c* are given in *Plate* III., and the diagrams *B* and *C* (fig. 1) represent enlarged sections of the conductor on the lines *b* and *c* respectively.

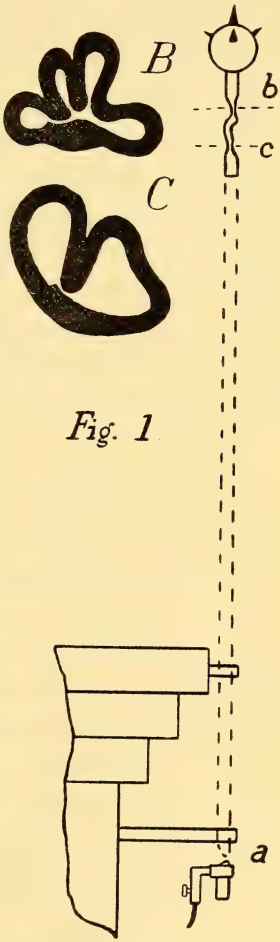

*Fig. 1*

The surface of the upper part of the tube is covered with little pit marks from about 0·1 to 0·5 mm. in diameter and 0·02 mm. deep. We are unable to say whether these marks

are due to the heating of the pipe by the discharge or to weathering. Probably the upper part of the tube which has collapsed was raised to a higher temperature than the rest of the pipe as it formed portion of the end of the electrode where the development of heat is always considerable. The tube as shown in one of the photographs (*Plate* III.) has apparently buckled as a column under the small weight of the ball ($3\frac{1}{2}$ lbs.), allowing the latter to subside vertically. This would indicate that the material at this point was in a plastic condition.

It is probable that the fusion at *a* figure 1 was due to an arc which occurred on account of the right angled bend in the conductor, and it is not to be considered as indicating more than a very local high temperature. On this view one should perhaps expect that the signs of fusion would appear in the right angled piece shown to the left of the tube in figure 1; the only signs of fusion however are found to the right of the tube on the outer edge of the collar.

Mr. G. H. Clark under whose supervision the conductor was erected, supplies the following particulars:—"The conductor was erected in 1889 on the chimney stack of the Hartley Vale Kerosene Refinery. The finial, which stood about 3 ft. above the cap of the chimney, consisted of a gun metal ball $3\frac{1}{2}$ inches in diameter, having one large centre point and four smaller radiating ones. The weight of the ball was about $3\frac{1}{2}$ lbs. The copper pipe connected the finial with a somewhat massive copper goose neck just below the cap of the chimney, which was attached to the conductor, consisting of a copper band $1 \times \frac{1}{8}$ inch. From the base of the chimney the conductor was run in a trench 18 inches deep some 30 feet, thence into a well 30 ft. deep, the band terminating in a grid, of $1 \times \frac{1}{8}$ inch copper, $2\frac{1}{2} \times 2\frac{1}{2}$ feet. This well supplied the works boiler with water; when the water became foul with the soakage from the Refinery it was usual to blow it out clean with a jet of

steam; this was being done when the storm occurred, the grid being suspended in the well, free from the bottom. From what I could gather at the time, some ten years ago, there appears to have been only one severe flash. The central point on the ball and two of the radiating ones were cut off and the pipe was fused at the goose-neck which connected it with the copper band. This was the only damage sustained. The copper band for a distance of 20 feet below the goose neck was tempered to a hardness of a steel band, so much so that in repairing the conductor, it was with some difficulty that the gun metal holdfasts could be made to hold, though these were driven into lead plugs and well caulked. When a holdfast was put in and the band struck to get the buckle out, one or two above would be sprung out of the plugs."

## ELECTRODYNAMIC ACTION OF THE CURRENT.

For steady currents uniformly distributed over the area of cross section, elementary considerations show, in the case of a solid cylinder of radius $a$, that the sum of the mechanical forces acting throughout the matter contained in unit length of the cylinder is given by the expression $4\,I_0^2/3a$ where $I_0$ is the total current flowing along the conductor, the forces at all points being directed radially inwards in planes at right angles to the axis of the cylinder. Under the same circumstances, for a cylindrical shell of inner radius $b$ and outer radius $a$, the corresponding expression is $4\,I_0^2\,(a+2b)/3\,(a+b)^2$, which if the shell is very thin reduces to $I_0^2/a$. With alternating currents for a cylindrical conductor where $a$ is the radius of the outer surface, J. J. Thomson "Recent Researches," § 268, gives as the maximum value of the magnetic force at a point in the cross section fixed by a radius $r$

$$\frac{2}{\sqrt{ar}}\,I_0 e^{-\beta\,(a-r)}$$

where $I_0$ is the total current flowing along the conductor

and $\beta = (2\pi\mu p/\sigma)^{\frac{1}{2}}$, $p/2\pi$ being the frequency of the current alternations, $\mu$ the magnetic permeability and $\sigma$ the specific resistance of the material of the conductor.

The maximum current flowing along a cylindrical shell of the conductor of radius $r$ and of thickness $dr$ is:—

$$I_0 e^{-\beta(a-r)}\left[\beta\sqrt{\frac{r}{a}}+\frac{1}{2\sqrt{ar}}\right]dr$$

The maximum value of the sum of the mechanical forces on unit length of such a shell is given by the product of the above expressions. For unit length of a cylindrical tube, of inner radius $b$ and outer radius $a$, the product becomes:—

$$\frac{2\beta}{a} I_0^2 e^{-2\beta a}\int_b^a e^{2\beta r}\,dr + \frac{I_0^2}{a} e^{-2\beta a}\int_b^a \frac{1}{r} e^{2\beta r}\,dr$$

The value of the first term is:—

$$\frac{I_0^2}{a}\left(1 - e^{-2\beta(a-b)}\right)$$

and that of the second lies between

$$\frac{I_0^2}{a}\log\frac{a}{b} \text{ and } \frac{I_0^2}{a}\log\frac{a}{b}\, e^{-2\beta(a-b)}$$

For copper $\mu = 1$ and $\sigma$ may be taken as 1,600. If we assume that the frequency of alternation in the discharge is $10^6$ per sec. then $\beta$ or $(2\pi\mu p/\sigma)^{\frac{1}{2}} = 50\pi$. With these values and as in the case of the tube under consideration $a/b$ differs little from unity, no term in the expression for the product except the first is of importance, and the maximum value of the sum of the forces acting radially inwards on unit length of the cylindrical tube may be written

$$\frac{I_0^2}{a}$$

or the force per unit area $\dfrac{I_0^2}{2\pi a^2}$

Where $a = 0{\cdot}9$ cms. the force in dynes per square centimetre will be given by $\frac{I_0^2}{500}$ where $I_0$ is measured in ampères.

If the pressure of an atmosphere is taken as equal to $10^6$ dynes per sq. cm. a current $I_0$ measured in ampères will produce an effect equivalent to that of an external pressure of $n$ atmospheres if $n = \frac{I_0^2}{500 \times 10^6}$ or $I_0 = 22000 \times \sqrt{n}$.

### Mechanical Considerations.

It is desired to estimate the pressure at which the tube under discussion collapsed ; such an estimation is difficult to make with any accuracy, because:—

*a.* The condition of the tube and the quality of the metal are not known.

*b.* The temperature of the metal at the moment of its collapse is quite unknown, and there are very few circumstances to guide one in estimating it, and

*c.* The theory of the collapse of tubes is imperfect.

Obviously all that can be done is to obtain approximate upper and lower limits of the pressure conditions at the time.

*a.* The material of which the tube was made would probably have a tensile strength of about 30,000 lbs. per square inch at ordinary temperatures, and an elastic limit of approximately 5,500 lbs. per square inch. Copper has no definite "compressive strength" properly so called, but there is a fairly well marked elastic limit in compression at about 3,500 lbs. per square inch. These figures decrease to a marked degree with increase of temperature; the tensile strength for example being reduced to approximately 20,000 lbs. per square inch at a temperature of 600° Fahr. Copper melts at a temperature of about 1,930°Fahr.(1054°C.) but experiments on the strength of copper with varying temperatures have not been carried beyond 1,100° Fahr.[1]

[1] The Effect of Temperature on the Tensile and Compressive Properties of Copper.—This Journal Vol. xxxi.

*b*. The above figures would apply if it were assumed that the tube at the moment of collapse was at the ordinary temperature. It is not probable that such was the case, and the temperature may obviously have been anything up to a limit just short of melting. The appearance of the collapsed tube would not lead one to suppose that the metal had reached the neighbourhood of its point of fusion, and this view is confirmed by the fact that the solder connecting the tube to the solid rod above does not appear to have been melted to any marked degree, if at all. It is obvious therefore that the temperature of the material at the time of collapse is a matter of speculation.

*c*. A large number of experiments have been made on the pressures necessary to produce collapse in tubes, of which the best known are those by Sir W. Fairbairn,[1] who carried out an elaborate series on tubes and boiler flues. None of the tubes were as small as that now under consideration, but the results indicate generally the action of the tubes when subject to external pressure. Professor Unwin made a fresh analysis of the results obtained by Fairbairn, and deduced several semi-empirical equations to represent the collapsing pressure under various conditions.[2] He also demonstrated clearly that the number of lobes into which the tube collapses depends on the ratio of the length to the diameter, increasing in a definite fashion as this ratio decreases. An illustration of this fact is seen in the tube under consideration, where at the end near the junction of the tube and the solid rod the conditions of a tube of short length compared with its diameter are approximated to, and where the number of lobes is large, while further down where the long-tube conditions obtain, the number of lobes is reduced to the minimum. The conditions of the tube are so indeterminate that it is unnecessary to discuss the formulæ in detail.

[1] Phil. Trans., 1858. [2] Proc. Inst. C. E., Vol. XLVI.

# OBITUARY NOTICE.

## CAPTAIN HUTTON, F.R.S.

CAPTAIN FREDERICK WOLLASTON HUTTON, F.R.S., F.G.S., C.M.Z.S., was at his death one of our oldest surviving Hon. Members, having been elected in 1888; those senior to him are but two, viz.: Sir JOSEPH HOOKER, G.C.S.I., elected in 1880, and Sir M. FOSTER, K.C.B., 1887. Captain HUTTON was the second son of the Reverend H. F. HUTTON, Rector of Spridlington and was born at Gate Burton, Lincolnshire, England, November 16th, 1836, he was educated at Southwell Grammar School and the Naval Academy at Gosport. After leaving Gosport he spent three years in the India Mercantile Marine, being over age for the Royal Navy; he then entered the army and served with the 23rd Royal Welsh Fusiliers in the Crimea in 1855-6, later he took part under Sir COLIN CAMPBELL in the relief and capture of Lucknow in 1857 and the defeat of the Gwalior mutineers, for which he received the medal and two clasps. On his return home he entered the Staff College, where he studied geology under Prof. RUPERT JONES; his career was a distinguished one, and he passed out as sixth on the list in 1860. In 1862 he was gazetted Captain and served as Deputy Assistant Quartermaster-General at Dublin.

In 1866 he went out to New Zealand, and in 1871 was appointed Assistant Geologist to the New Zealand Survey, Curator of the Otago Museum in 1873 and Professor of Natural Science in the University of Otago 1887. In 1880 he was appointed to the Professorship of Biology at Canterbury College, Christchurch: in 1893 he resigned the chair to become Curator of the Canterbury Museum. He was

elected a Corresponding Member of the Zoological Society in 1872. He was a Corresponding Member of the Royal Society of Tasmania, Correspondent du Mus d'Histoire Nat. Paris ; Academy of Natural Science, Philadelphia ; Ornith. Ver. Wien and K. K. Geol. Reichsanst. Wien. In 1891 he was awarded the Clarke Memorial Medal by the Royal Society of New South Wales for meritorious contributions to the Geology of Australasia. In 1892 he was elected F.R.S.; he was President of the Australian Association for the Advancement of Science at the Hobart Meeting 1902, and was President of the New Zealand Institute at the time of his death, which took place on October 27th last, on board the R.M.S. *Rimutaka* when returning from England to New Zealand.

He took a leading part in the scientific life both at Dunedin and at Christchurch, and his influence was felt not only over New Zealand and Australia, but throughout the scientific world. He was the author of a large number of valuable papers on the geology, botany and zoology of New Zealand and other subjects, he was also a frequent and valued contributor to "Nature"; his last contribution appeared in it a month or two before his death. I do not attempt to notice his work in detail, as I think that should be done by one specially qualified in the subjects to which our late colleague devoted himself.

One of his first papers was an essay upon the "Importance of a knowledge of geology to military men" published in the Journal of the Royal United Service Institution in 1862. Many of his papers were published in the Transactions of the New Zealand Institute, the Proceedings of the Linnean Society of New South Wales, the Proceedings of the Zoological Society, the Ibis, the Geological Magazine, and the Reports of the Australasian Association for the Advancement of Science. In the Royal Society's List of

Scientific Papers there are 133 entries under his name, from 1862 to 1884 (the date of the last published vol.) but numerous other papers have since been published by him. As shown by his published papers and addresses, from his subaltern days onwards, he was deeply interested in the subject of evolution; in 1899 appeared "Darwinism and Lamarckism Old and New," in 1902 "The Lesson of Evolution." In addition to the more purely scientific papers he published a Class Book of Elementary Geology 1875, and in association with JAMES DRUMMOND "Nature in New Zealand" 1903, and "The Animals of New Zealand" 1904. A short paper upon "What is Life?" written by him during his visit home, appeared in the November number of Hibbert's Journal.

The following extract from the "Life and Letters of Charles Darwin" will give an idea of what two of our greatest men of science thought of HUTTON'S scientific judgment at a time when he was only 25 years of age. In writing to JOSEPH HOOKER, DARWIN says:—"I quite agree with what you say on Lieutenant HUTTON'S review in the "Geologist," (on Darwin's "Origin of Species," 1861, p. 132), who he is I know not; it struck me as very original. He is one of the very few who see that the change of species cannot be directly proved, and that the doctrine must sink or swim according as it groups and explains phenomena. It is curious to see how few judge it in this way, which is clearly the right way."

Captain HUTTON was an ardent worker and observer and was ever ready to give a generous support to the efforts of others; a close reasoner, of clear and independent thought, a pleasant companion and a loyal friend. He greatly disliked publicity, he had a soldier's directness and simplicity of purpose and a strong abhorrence of anything in the nature of pretentions or shams.

December, 1905. A. LIVERSIDGE.

# ABSTRACT OF PROCEEDINGS

*a*—May 3, 1905.

ABSTRACT OF PROCEEDINGS

OF THE

# Royal Society of New South Wales.

## ABSTRACT OF PROCEEDINGS, MAY 3, 1905.

The Annual General Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, May 3rd, 1905.

Prof. LIVERSIDGE, M.A., LL.D., F.R.S., Vice-President, in the Chair.

Thirty-seven members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ended 31st March, 1905, was presented by the Hon. Treasurer, and adopted:—

GENERAL ACCOUNT.

| RECEIPTS. | | £ s. d. | £ s. d. |
|---|---|---|---|
| Subscriptions | One Guinea ... ... ... | 68 5 0 | |
| | " " Arrears ... ... | 11 14 0 | |
| | Two Guineas ... ... ... | 369 12 0 | |
| | " " Arrears ... ... | 99 11 0 | |
| | Advances ... ... ... | 4 4 0 | |
| | | | 553 6 0 |
| Composition for Life Membership ... ... | | | 10 10 0 |
| Parliamentary Grant on Subscriptions received— | | | |
| Vote for 1904-1905 ... ... ... ... | | 250 0 0 | |
| | | | 250 0 0 |
| Rent ... ... ... ... ... ... ... ... ... | | | 81 5 0 |
| Sundries ... ... ... ... ... ... ... ... | | | 20 11 4 |
| Clarke Memorial Fund ... ... ... ... ... ... | | | 250 0 0 |
| Total Receipts ... ... ... ... | | | 1165 12 4 |
| Balance on 1st April, 1904 ... ... ... ... ... | | | 10 15 10 |
| | | | £1176 8 2 |

N.B.—The Outstanding Accounts amount to £125 2s. 1d.

| Payments. | £ s. d. | £ s. d. |
|---|---|---|
| Advertisements ... ... ... ... ... | 19 3 0 | |
| Assistant Secretary ... ... ... ... | 250 0 0 | |
| Books and Periodicals ... ... ... ... | 54 3 3 | |
| Bookbinding ... ... ... ... ... | 3 19 6 | |
| Collector ... ... ... ... ... ... | 3 7 2 | |
| Expenses at Meetings ... ... ... ... | 26 1 6 | |
| Freight, Charges, Packing, &c.... ... ... | 4 0 11 | |
| Furniture and Effects ... ... ... ... | 1 4 7 | |
| Gas ... ... ... ... ... ... ... | 18 9 3 | |
| Housekeeper ... ... ... ... ... | 10 0 0 | |
| Insurance ... ... ... ... ... ... | 9 7 8 | |
| Interest on Mortgage ... ... ... ... | 42 0 0 | |
| Office Boy ... ... ... ... ... ... | 24 7 6 | |
| Petty Cash Expenses ... ... ... ... | 8 13 4 | |
| Postage and Duty Stamps ... ... ... | 24 15 0 | |
| Printing ... ... ... ... ... . | 29 18 0 | |
| Printing and Publishing Journal ... ... | 269 19 0 | |
| Printing Extra Copies of Papers ... ... | 9 9 6 | |
| Rates ... ... ... ... ... ... | 41 3 6 | |
| Repairs ... ... ... ... ... ... | 0 11 9 | |
| Stationery ... ... ... ... ... ... | 19 10 9 | |
| Sundries . . ... ... ... ... ... | 22 14 5 | |
| Total Payments ... ... | | 892 19 7 |
| Building and Investment Fund, Composition for Life Membership ... ... ... | | 10 10 0 |
| Clarke Memorial Fund—Loan repaid ... ... | 250 0 0 | |
| Interest to date ... ... ... ... | 3 10 0 | |
| | | 253 10 0 |
| Bank Charges ... ... ... ... ... | | 2 18 7 |
| Balance on 31st March, 1905, viz.:— | | |
| Cash in Union Bank... ... ... ... | 6 10 0 | |
| Cash in hand... ... ... ... ... | 10 0 0 | |
| | | 16 10 0 |
| | | £1176 8 2 |

## BUILDING AND INVESTMENT FUND.

| Dr. | £ s. d. | £ s. d. |
|---|---|---|
| Loan on Mortgage at 4% ... ... ... | | 1400 0 0 |
| Composition for Life Membership, 1902 ... | 21 0 0 | |
| Ditto, 1904-5 ... ... ... ... ... | 10 10 0 | |
| Interest ... ... ... | 0 11 0 | |
| | | 32 1 0 |
| | | £1432 1 0 |

| Cr. | £ s. d. | £ s. d. |
|---|---|---|
| Deposit in Government Savings Bank, March 31st, 1905 ... ... ... ... ... | | 32 1 0 |
| Advance to General Account 31st March, 1897 | 8 0 6 | |
| Balance 31st March, 1905 ... ... ... | 1391 19 6 | |
| | | 1400 0 0 |
| | | £1432 1 0 |

## CLARKE MEMORIAL FUND.

| Dr. | £ s. d. |
|---|---|
| Amount of Fund, 31st March, 1904 ... ... ... ... | 469 9 11 |
| Interest to 31st March, 1905 ... ... ... ... ... | 16 4 3 |
| | £485 14 2 |

| Cr. | £ s. d. |
|---|---|
| Deposit in Savings Bank of New South Wales, March 31, 1905 | 241 8 3 |
| Deposit in Government Savings Bank, March 31, 1905 ... | 244 5 11 |
| | £485 14 2 |

Audited and found correct, as contained in the Books of Accounts.

DAVID FELL, C.A.A. ..................
T. TYNDALL PETERSON, A.S.I.A. } *Honorary Auditors.*

Sydney, 28th April, 1905.

D. CARMENT, F.I.A., F.F.A. *Honorary Treasurer.*
W. H. WEBB. *Assistant Secretary.*

A vote of thanks was passed to the Hon. Auditors, viz., Mr. David Fell, C.A.A., and Mr. T. Tyndall Peterson, A.S.I.A., for their services.

Dr. Marden, M.A., and Mr. W. A. Dixon, F.I.C., were appointed Scrutineers, and Dr. Spencer deputed to preside at the Ballot Box.

There being no other nominations the following gentlemen were declared duly elected Officers and Members of Council for the current year :—

**President :**

H. A. LENEHAN, F.R.A.S.

**Vice-Presidents :**

| | |
|---|---|
| Prof. LIVERSIDGE, LL.D., F.R.S. | F. B. GUTHRIE, F.I.C., F.C.S. |
| Prof. WARREN, M. Inst. C.E., Wh.Sc. | F. H. QUAIFE, M.A., M.D. |

Hon. Treasurer:
D. CARMENT, F.I.A., F.F.A.

Hon. Secretaries:

| | |
|---|---|
| J. H. MAIDEN, F.L.S. | G. H. KNIBBS, F.R.A.S. |

Members of Council:

| | |
|---|---|
| S. H. BARRACLOUGH, Assoc. M. Inst. C.E. | T. H. HOUGHTON, M. Inst. C.E. |
| Prof. T. W. E. DAVID, B.A., F.R.S. | H. C. RUSSELL, B.A., C.M.G., F.R.S. |
| H. DEANE, M.A., M. Inst. C.E. | HENRY G. SMITH, F.C.S. |
| T. F. FURBER, F.R.A.S. | WALTER SPENCER, M.D. |
| W. M. HAMLET, F.I.C., F.C.S. | J. STUART THOM |

The certificate of one candidate was read for the third time, of one for the second time, and of six for the first time.

The following gentleman was duly elected an ordinary member of the Society, viz:—

Harker, George, D.Sc., Petersham.

Thirty-three volumes, 410 parts, 39 reports, 10 pamphlets, 1 map, and 1 atlas of charts, total 494, being portion of the donations received since the last meeting, were laid upon the table and acknowledged.

The following letter was received from Mr. L. W. Marcker, Consul for Denmark:—

Consulate of Denmark, Sydney, N.S.W.
February 9th, 1905.

Sir,—The sympathy which has been shown by men of science from all parts of the world over the death of the young Danish scientist Professor Mils R. Finsen, and the numerous foreign enquiries which have been made, asking permission to take part in the movement started in Denmark to raise funds, according to the deceased's last wish, to enable the scientific institution called the Finsens Institute (to which Finsen presented the Nobel Prize won by him) to continue the researches, so ably begun by him, has resulted in that the original Danish Committee now has become a universal one. Sub-committees have been started in England, all over the Continent, and in America. At the request of the Danish Committee, the Consulate has received instructions from the Ministry for Foreign Affairs, Copenhagen, to place the matter before the scientific bodies in Sydney, I therefore, herewith have the honour to request you

kindly to be good enough to direct the attention of the members of your honoured Society to the movement. The Consular instructions are also to give any local movement which might be started, all possible assistance, and I need hardly say, that any information or help I can give will be given with very great pleasure.

I have etc.,

L. W. Marcker, Consul.

Messrs. J. H. Maiden and G. H. Knibbs, Hon. Secretaries,
Royal Society of N. S. Wales.

Letters were received from Mr. C. O. Burge, M. Inst. C.E., acknowledging receipt of copy of resolution carried at the previous Council meeting. Also tendering his resignation as a member of the Society owing to his approaching departure for good from Australia.

The Chairman made the following announcements:—

1. The British Science Guild.—It has been a frequent subject of comment that, although the contribution of this country to the progress of science has been second to that of no other nation, the English people do not manifest that interest in, and belief in the powers of science, which are noticeable among the peoples of the Continent, or of America. In spite of the efforts of many years, the scientific spirit, essential to all true progress, is still too rare, and, indeed, is often sadly lacking in some of those who are responsible for the proper conduct of many of the nation's activities. It is with the view of attempting to remedy this evil, and to bring home to all classes the necessity of applying scientific treatment to affairs of all kinds, that the proposal is made to bring together those convinced of this necessity by founding "The British Science Guild." The objects and organization of the Guild, which will be entirely disconnected from party politics, are as follows:—(1) To bring together as members of the Guild all those throughout the Empire interested in science and scientific method, in order, by joint action, to convince the people, by means of publications and meetings, of the necessity of

applying the methods of science to all branches of human endeavour, and thus to further the progress and increase the welfare of the Empire. (2) To bring before the Government the scientific aspects of all matters affecting the national welfare. (3) To promote and extend the application of scientific principles to industrial and general purposes. (4) To promote scientific education by encouraging the support of universities and other institutions where the bounds of science are extended, or where new applications of science are devised. Methods of attaining these objects: (*a*) by publications; (*b*) by meetings; (*c*) by conferences and lectures; (*d*) by deputations. All British subjects, both men and women, are eligible for membership of the Guild. It was resolved that life members of the Guild shall pay, on admission, two guineas, which includes a registration fee of 2s. 6d., and that annual subscribers shall pay, on admission, 5s., and in each subsequent year 2s. 6d. It was also resolved that donations may be accepted.

2. The present position and prospects of the International Catalogue of Scientific Literature. His remarks will be published in the June Abstract.

3. The forthcoming meeting of the British Association for the Advancement of Science to be held at Cape Town, South Africa, commencing August 15th, 1905.

4. The death (on April 30th) of Mr. CHARLES MOORE, F.R.B.S., C.M.Z.S., the following resolution proposed by Mr. J. H. MAIDEN and seconded by Dr. F. H. QUAIFE, was duly carried, the members standing:—"That the Royal Society of New South Wales has heard with deep regret of the death of Mr. CHARLES MOORE who had been a member since the year 1856, and who for two years was its oldest member. He served on the Council continuously from the year 1868, was honorary secretary from 1871 to 1874, and vice-president for nine years, between the years 1878 and

1900. That this Society desires to convey its sympathy with the relatives of their colleague."

THE FOLLOWING PAPERS WERE READ:

1. "On the occurrence of Calcium oxalate in the barks of the Eucalypts," by HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

The author announces the presence, in large quantities, of calcium oxalate in the barks of several species of Eucalyptus. It is similar in form and appearance in all species, being well defined monoclinic crystals in stout microscopic prisms, averaging 0·0174 mm. in length, and 0·0077 mm. in breadth and containing one molecule of water. A peculiarity of these is the tendency to form twins geniculate in appearance; twinned forms being pronounced in some species. From botanical and chemical evidence it is assumed that *Eucalyptus salmonophloia* of West Australia and *E. oleosa* of New South Wales belong to the same species, and that the latter tree, which most often occurs as a "Mallee," is only the degenerate stage of the former. The theory is advanced that some of the "mallees," or shrubby Eucalypts, have been formed through the poisoning effect of the excess of oxalic acid, acting for a long time upon species which originally grew as large trees. The tannins in those Eucalyptus barks containing a large amount of calcium oxalate are of very good quality, light in colour, astringent, easily soluble, and should make leather of good quality. On evaporating the extract to dryness on the water bath but little darkening takes place, and the product is still readily soluble. This class of Eucalyptus barks should, therefore, make excellent tanning extracts. From the bark residue the calcium oxalate should be profitably extracted, and the oxalic acid obtained cheaply from this, practically as a by-product. The air dried bark of *Eucalyptus salubris*, the "Gimlet" of West Australia, gives

30·5% of total extract and 18·6% of tannin absorbed by hide powder, and contains 16% of calcium oxalate. The bark of *Eucalyptus gracilis* contains 16·66% of calcium oxalate; that of *E. Behriana* 16·5%; of *E. oleosa* 10·64%; of *E. dumosa* 9·8%; and of *E. salmonophloia* 8·34%. The barks of all the Eucalypts tested contain calcium oxalate, although in some species in very small amount.

2. "Notes of astronomical interest, dealing with the past eighteen months, showing the progress and deductions made during that period," by H. A. LENEHAN, F.R.A.S., Acting Government Astronomer.

EXHIBITS.

A collection of fossil Halysites from the Orange district was exhibited by Mr. C. A. Süssmilch, F.G.S.

Prof. LIVERSIDGE vacated the Chair and Mr. H. A. LENEHAN, F.R.A.S. was installed as President for the ensuing year.

Mr. LENEHAN thanked the members for the honour conferred upon him.

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## ABSTRACT OF PROCEEDINGS, JUNE 7, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, June 7th, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Thirty-six members were present.

The minutes of the preceding meeting were read and confirmed.

Dr. GEORGE HARKER enrolled his name and was introduced.

Mr. T. H. HOUGHTON, M. Inst. C.E., and Mr. HENRY G. SMITH, F.C.S., were appointed Scrutineers, and Mr. W. M. HAMLET, F.I.C., F.C.S., deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of six for the second time, and of four for the first time.

The following gentleman was duly elected an ordinary member of the Society. viz.:—

ANDERSON CHARLES, M.A., B.Sc. Edin.; Roslyn Gardens.

Forty-seven volumes, 231 parts, 6 reports, and 10 pamphlets, total 294 received as donations, were laid upon the table and acknowledged.

The following letter was received from Miss van Heuckelum, acknowledging the receipt of a letter of sympathy on the occasion of the death of Mr. CHARLES MOORE:—

6 Queen-street, Woollahra, May 22nd, 1905.

The Hon. Secretaries, Royal Society of New South Wales.

Gentlemen,—I beg to acknowledge the receipt of your letter of the 4th instant, conveying the resolution carried by the members of your Society at the Annual General Meeting in respect to the late CHARLES MOORE, and I now desire to return thanks on behalf of myself and the other relatives for the kind sympathy expressed by the members, and for their eulogistic references to the deceased's past connection with your Society.

I remain, gentlemen, yours respectfully,

MARGARETTA VAN HEUCKELUM.

The following report was presented by Professor LIVERSIDGE at the Annual General Meeting, 3rd May, 1905:—

INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

In 1903 I was appointed by the Council of this Society acting as the Regional Bureau for New South Wales, to represent this State at the Council Meetings held in London in May last. I duly attended the meetings and now have the honour to make the following report. The Royal Society of London commenced the work by compiling Catalogues of Scientific Papers (printed between 1800 and 1883) in twelve large quarto volumes, the first volume of which was issued in 1867. In it the titles are arranged solely under the authors' names. A catalogue of the papers published since, *i.e.*, between 1884 and 1900 is now in hand, and a subject index is also nearly completed.

The possibility of preparing a complete catalogue of current scientific literature was considered by the Royal Society in 1893, but as it was apparent that the work was beyond the resources of the Royal Society, or indeed of any single body, the society sought the opinion of representative foreign bodies and individuals and the replies being favourable, steps were taken to summon an International Conference. This conference, at which I was present as a Delegate, took place in London on July 14th to 17th, 1896, and was attended by delegates appointed by the Governments of Canada, Cape Colony, Denmark, France, Greece, Hungary, India, Italy, Japan, Mexico, Natal, the Netherlands, New South Wales, New Zealand, Norway, Queensland, Sweden, Switzerland, the United Kingdom, and the United States. It was then unanimously resolved to compile and publish a complete catalogue of current scientific literature, arranged both according to subject matter and authors' names. The Royal Society was requested to appoint a committee to further consider the system of classification to be adopted and other matters, and it was decided to establish the Central Bureau in London.

At the second International Conference held in London on October 11th to 13th, 1898, several questions were settled and a provisional International Committee appointed which afterwards met in London on August 1st to 5th, 1899, when the work was still further expedited and the Royal Society requested to organise the Central Bureau and make all necessary arrangements so that the preparation of the catalogue might be commenced in 1901.

A third International Conference was held in London on June 12th and 13th, 1900, at which all financial and other difficulties were removed by the Royal Society agreeing to act as publishers and to advance the funds necessary to start the enterprise. The supreme control over the catalogue is now vested in an International Convention which is to meet in London in 1905, in 1910, and every tenth year afterwards, to reconsider, and if necessary, to revise the regulations for carrying out the work of the catalogue. In the interval between two successive meetings of the Convention

the administration of the catalogue is carried out by the International Council, the members of which are appointed by the Regional Bureaus.

The total expenditure from July 1st, 1900 to February 29th 1904, has been £10,153, and the total amount received from subscribing bodies was £6,755 ; eventually the publication will pay its way, but it may be some time before the debt to the Royal Society will be extinguished. The financial support given by the different countries is shown in the following list. New Zealand has now become a contracting body:—Austria £165, Canada £119, Cape Colony £109, Denmark £102, Egypt £17, Finland £45, France £754, Germany £901, Greece £34, Holland £133, Hungary £68, India and Ceylon £471, Italy £459, Japan £255, Mexico £85, New South Wales £34, New Zealand £17, Norway £85, Nova Scotia £17, Orange River Colony £17, Poland £17, Portugal £17, Queensland £34, Russia £512, South Australia £34, Sweden £85, Switzerland £119, United Kingdom £765, United States £1,251, Victoria £17, Western Australia £17—Total £6,755.

It has been suggested that special efforts should be made by the Regional Bureaus to bring the catalogue under the notice of scientific workers, and to secure an increase in the number of subscribers The whole of the first and second issues of the International Catalogue of Scientific Literature have been published with the exception of the volumes on botany and zoology; the third annual issue is in preparation and several of them are already in the press. The number of entries in the author-catalogue of the first annual issue was 43,447, and the total number of entries in that issue was 149,768. The numbers of books and papers indexed in the volumes of the second annual issue are as follows :—A. Mathematics 1,843; B. Mechanics 841 ; C. Physics 2,433 ; D. Chemistry 5,632 ; E. Astronomy 1,223 ; F. Meteorology 1,988; G. Mineralogy 1,307; H. Geology 1,702; J. Geography 2,022 : K. Palæontology 638 ; L. General Biology, 689; M. Botany 6,339; N. Zoology 7,131; O. Anatomy 1,424; P. Anthropology 1,861; Q. Physiology 9,671; R. Bacteriology 3,132. The

total number of entries in the author catalogue of the second annual issue is therefore 49,876, an increase of 6,429, or about 15% more than the number in the first annual issue. The total number of pages in the first annual issue is 8,387.

The following table shows the number of slips *received* and the instalments in which they were supplied to the Central Bureau:—

| | | | | |
|---|---|---|---|---|
| Germany ... ... ... | 146,552 | slips in | 59 | instalments |
| France ... ... ... | 46,702 | „ | 38 | „ |
| United Kingdom ... ... | 43,484 | „ | 166 | „ |
| United States ... ... | 37,688 | „ | 68 | „ |
| Russia ... ... ... | 21,071 | „ | 5 | „ |
| Italy ... ... ... ... | 13,473 | „ | 25 | „ |
| Holland ... ... ... | 6,657 | „ | 17 | „ |
| Austria ... ... ... | 6,379 | „ | 2 | „ |
| Poland ... ... ... | 3,492 | „ | 8 | „ |
| India and Ceylon ... ... | 2,231 | „ | 39 | „ |
| Japan ... ... ... | 2,208 | „ | 10 | „ |
| Switzerland ... ... | 1,932 | „ | 7 | „ |
| Hungary ... ... ... | 1,745 | „ | 4 | „ |
| Denmark ... ... ... | 1,722 | „ | 17 | „ |
| Sweden ... ... ... | 1,457 | „ | 4 | „ |
| Victoria ... ... ... | 1,445 | „ | 3 | „ |
| Norway ... ... ... | 1,303 | „ | 12 | „ |
| New South Wales ... ... | 1,016 | „ | 5 | „ |
| Finland ... ... ... | 707 | „ | 8 | „ |
| South Africa ... ... | 645 | „ | 4 | „ |
| Belgium ... ... ... | 584 | „ | 2 | „ |
| Canada ... ... ... | 537 | „ | 11 | „ |
| New Zealand ... ... | 327 | „ | 3 | „ |
| South Australia ... ... | 130 | „ | 4 | „ |
| Western Australia ... | 16 | „ | 1 | „ |
| | 343,503 | „ | 522 | instalments |

It was originally intended that the catalogue should not only contain the titles of papers, but that their subject matter should be fully indexed also; financial considerations have, however, led to the number of subject-entries being at present limited in number. The title slips received at the Central Bureau very often showed that the papers were insufficiently indexed, especially in the lists of new species in botany and zoology; also chemistry; in many cases the Central Bureau has made good these deficiencies. The

Executive Committee urge that efforts should be made in all countries to supply fuller information as to the contents of papers; if this were done the catalogue would be much more complete and the cost would be much decreased, and all Journals are urged to index each paper and attach the registration numbers at the time of publication.

At the meeting of the International Council held at the Royal Society's House, London, May 23rd and 24th, 1904, it was resolved in consequence of the success achieved by the International Catalogue of Scientific Literature, and of its great importance to scientific workers, to recommend that its publication be continued The agreement with the contracting countries was made in the first instance for five years only, in case the publication of the catalogue should fail financially or in other ways. It was also decided to spend £100 in making the catalogue known, and to take steps to invite the cooperation of other countries not yet represented on the council, *e.g.* Spain, the Balkan States, South American Republics, etc.

The proposal to publish additional volumes upon, *a.* Medicine and Surgery; *b.* Agriculture, Horticulture and Forestry; *c.* Technology (various branches) was discussed, and it was decided that the executive committee should take the suggestion into fuller consideration and bring it under the notice of the International Convention in July 1905. It was also resolved that all alterations in the schedules should be collected and edited by the Central Bureau prior to submission to the Regional Bureaus for their opinions, and that the schemes should be edited by a special committee before being submitted to the International Convention.

(Signed) A. Liversidge.

A circular letter from Heidelberg was read respecting the erection of a monument in that city in memory of Robert Bunsen, and as an expression of the debt of gratitude which the world owes him for his great contributions to science and technology. Professor Bunsen was an Honorary Member of the Royal Society of New South

Wales from 1895. Contributions will be received by the Hon. Secretaries for transmission to Heidelberg, or they may be sent direct to the Hon. Treasurer Herr A. RODRIAN, Stadtrat (in Firma C. Desaga) Heidelberg, Germany.

THE FOLLOWING PAPER WAS READ:

"On the so-called Gold Coated Teeth in Sheep." By A. LIVERSIDGE, LL.D., F.R.S., Professor of Chemistry, University of Sydney.

Paragraphs have appeared recently in some of the London and Sydney newspapers, stating that gold coated teeth have been found in Australian sheep. I have recently received the lower half of a sheep's jaw bone from Dubbo, the teeth of which are more or less completely incrusted with a yellow metallic substance, but more like iron pyrites (marcassite) or brass than gold. The deposit is about $\frac{1}{32}$ of an inch, or less than 1 mm. in thickness. Under a half inch objective it is seen to be made up of thin translucent layers but there is no recognisable organic structure. The metallic lustre is due to the way in which the light is reflected from the surface of the superimposed films. The scale partly dissolves in dilute acids. The residue consists of filmy organic matter, still possessing a metallic sheen although white in colour instead of yellow. The chemical examination shows that the incrustation on the teeth is merely a tartar-like deposit made up principally of calcium phosphate and organic matter.

*Note.*—Professor LIVERSIDGE also showed a calculus of a similar metallic looking character from a sheep's stomach, deposited in distinct layers round a piece of twig, but of rather a darker bronze tint than the substance on the teeth —this specimen belongs to the Sydney Technological Museum, and was kindly lent for exhibition by the Curator, Mr. R. T. BAKER.

EXHIBITS.

1. Mr. J. H. MAIDEN exhibited and described some of the identical plants gathered by Banks and Solander on Captain Cook's first expedition in 1770.

2. Mr. HENRY DEANE exhibited photograph of a painting of Sydney, date about 1810. Explanatory remarks concerning it were made by Mr. J. J. FLETCHER and Mr. DEANE; the latter kindly presented the photo to the Society. Mr. DEANE also showed a portrait of the Viscount Sydney after whom this city was named.

3. Mr. HENRY G. SMITH exhibited specimens of alcohol from Germany, which he described at some length. Remarks were made by Mr. G. H. KNIBBS, Prof. LIVERSIDGE, Mr. R. T. BAKER, Mr. S. H. BARRACLOUGH, and Dr. G. HARKER.

4. Mr. D. CARMENT exhibited and explained the working of a new calculating machine.

5. Dr. WALTER SPENCER exhibited specimens of woven Piña fibre, collection of Chinese gold coins, objects which formed the sole export of the Loo-Choo Islands 30 years ago, &c.

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## ABSTRACT OF PROCEEDINGS, JULY 5, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, July 1st, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of six candidates were read for the third time, of four for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Board Peter, M.A. Syd.; Under Secretary and Director of Education, Department of Public Instruction, Sydney.

Foy, Mark; Merchant, "Eumemering," Bellevue Hill, Rose Bay.

Hooper, George; Registrar, Sydney Technical College, p.r. 'Branksome,' Henson-street, Summer Hill.

Jensen, Harold Ingemann; Macleay Fellow of the Linnean Society of N.S. Wales, 31 Arcadia Road, Glebe Point.

Moors, Elphinstone MacM., M.A. Melb., F.I.A., Lond.; 'Kallista,' Raglan Street, Mosman.

Turner, John William; Assistant Under Secretary, Department of Public Instruction; Department of Public Instruction, Sydney.

Mr. W. A. Dixon, by permission of the President, made the following remarks:—He had often found that young men were quite willing to work out any investigation, but that they were not aware of any subject which would repay them; he, therefore, desired to suggest one in which he had found no information. He thought it deserved investigation, but had no time himself to attempt it. He had in his dining-room a Fletcher's gas fire, an upright fire-clay block, with tufts of asbestos heated to radiation of heat point by a Bunsen flame. Some years ago, sitting in front of this it occurred to him that it would be an improvement to convert the colorless flame to a colored one, and therefore twisted some wires into a rope and saturated this with brine to obtain a sodium flame. Next night the

fire having got hot, he introduced the saturated wire at the base of the flames, and immediately found a great reduction in the radiation, so that he felt quite cool. Removal of the wires and re-insertion several times always produced the same effect.

The subject he had to suggest was, therefore, "The Radiation from Coloured Flames." To this might very well be added the absorption of radiant heat by coloured glass, which varies much. In this part it would be necessary to use coloured glass of standard light penetration, such as is used in Lovibond's Tintometer.

Remarks were made by Dr. F. H. QUAIFE and Mr. G. H. KNIBBS.

The President made the following announcements:—

1. The death of the Hon. Sir AUGUSTUS CHARLES GREGORY K.C.M.G., M.L.C., F.R.G.S., Brisbane, who was elected an Honorary Member of the Society in 1875, and awarded the Clarke Memorial Medal in 1896. It was resolved that a letter of condolence be forwarded to the relatives of the deceased.

2. That the Officers and Committee of the Engineering Section had been elected for the present Session:—

Sectional Committees—Session 1905.

Section K. Engineering.

Chairman—JOSEPH DAVIS, M. Inst. C.E.

Hon. Secretary—J. HAYDON CARDEW, Assoc. M. Inst. C.E.

Committee—T. H. HOUGHTON, M. Inst. C.E., M. I. Mech. E., G. R. Cowdery, Assoc. M. Inst. C.E., T. W. Keele, M. Inst. C.E., W. E. Cook, M. Inst. C.E., NORMAN SELFE, M. Inst. C.E., M. I. Mech. E., J. I. HAYCROFT, Assoc. M. Inst. C.E., J. N. C. MACTAGGART, B.E., R. T. MCKAY, C.E., F. M. GUMMOW, M.C.E.

Past Chairmen—J. M. SMAIL, M. Inst. C.E., H. G. MCKINNEY, M. E., M. Inst. C.E., S. H. BARRACLOUGH, M.M.E., Assoc. M. Inst. C.E.

Thirty-six volumes, 259 parts, 9 reports, 127 pamphlets, and 1 photograph, total 432, received as donations, were laid upon the table and acknowledged.

THE FOLLOWING PAPER WAS READ:

1. "Observations on the Illustrations of the Banks and Solander Plants," by J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens, Sydney.

The issue of the third and final volume and plates, from the coppers engraved in the 18th century, from drawings by Nodder, Cheveley, and the two Millers, prepared under the direction of Banks, and depicting over 400 plants collected by him in 1770, during Cook's first voyage, is, to Australians at least, an important historical event, which assuredly demands the most marked emphasis that Australians can give it. The present work has been written by Mr. James Britten of the British Museum, with the authority of the trustees of that institution. Many of Banks' plants depicted were presented by the trustees to the National Herbarium, Sydney. The scope of this work is explained, and the proposed changes in nomenclature are indicated and compared with the names in the "Flora Australiensis." This handsome publication, apart from its historical value, is a notable addition to existing iconographies of Australian plants.

Remarks were made by Mr. W. J. CLUNIES ROSS, Mr. R. T. BAKER, Mr. W. M. HAMLET, and the Author.

EXHIBITS:

1. Professor LIVERSIDGE, M.A., F.R.S., exhibited "Fused Quartz," also special apparatus.

2. Mr. T. H. HOUGHTON, M. Inst. C.E., exhibited Sections and illustrations of the Locking Bar Pipes as used for the Coolgardie Water Supply, also specimen of the Universal Joint.

3. Professor T. W. E. DAVID, B.A., F.G.S., F.R.S., exhibited a collection of Thinolites. Some remarks were made by Mr. CHARLES ANDERSON.

## ABSTRACT OF PROCEEDINGS, AUGUST 2, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, August 2nd, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty-five members were present.

The minutes of the preceding meeting were read and confirmed.

Mr. GEORGE HOOPER enrolled his name and was introduced.

Messrs. W. J. CLUNIES ROSS and F. B. GUTHRIE were appointed Scrutineers, and Mr. W. M. HAMLET deputed to preside at the Ballot Box.

The certificates of four candidates were read for the third time, of one for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Blakemore, George Henry, General Manager for the Great Cobar Mining Syndicate, Lithgow.

Hoskins, George I., Engineer, Burwood Road, Burwood.

Miller, James Edward, Cobar.

Scott, Ernest Kilburn, Electrical Engineer, The University, Sydney.

The Chairman announced (1) that the Society's Journal, Vol. XXXVIII., for 1904 was in the binder's hands and would be distributed as speedily as possible. (2) That the Second Popular Science Lecture 1905, on "The Monotremes and the Origin of Mammals," (illustrated by lantern slides) by J. P. HILL, D.Sc., F.L.S., Lecturer in Embryology etc., Sydney University, would be delivered on Friday, 18th August at 8 p.m.

Forty-four volumes, 241 parts, 7 reports and 15 pamphlets, total 307, received as donations since the last meeting were laid upon the table and acknowledged.

The following letter was read :—

Rosalie, 23rd July, 1905.

To the Hon. Secretaries, Royal Society of N.S. Wales, Sydney.

Dear Sirs,—I have the honour to acknowledge the receipt of your letter of 15th instant, conveying to us the kind expressions of sympathy expressed by the Royal Society of New South Wales, Sydney. I, on behalf of myself and brother, have to request that you will kindly thank them on our behalf for their sympathy with us in our late bereavement.

Yours faithfully,

F. W. GREGORY.

THE FOLLOWING PAPER WAS READ:

"The refractive indices, with other data, of the oils of 118 species of Eucalyptus," by HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

In this paper the author records the refractive index, the specific gravity, the specific refractive energy and the solubility in alcohol of the oil of each species. The material was distilled at the Museum, and most of it had been prepared for the work "Research on the Eucalypts and their Essential Oils," by Mr. R. T. BAKER and himself, so that it was of undoubted origin. The oils of those species which have been obtained since that work was published are also included. By working upon the oils of such a large number of species it was possible to arrange the results in some order. The specific refractive energy results cannot be used to any great extent for the purpose of classification, but if the refractive index be multiplied by 10 times the solubility in 70% alcohol, (sp. gr. 0·8722 at 15·5° C.) a very good arrangement of the eucalyptol oils can be made. Those oils which contained eucalyptol in excess had, as a rule, the least refractive index, and were the most soluble in alcohol. As the pinene increased in amount the solubility diminished and although the refractive index remained

much the same, yet, the resulting figures increased considerably. The solubilities were taken in tenths, and the temperature for all the determinations was 16° C. The oils of the 51 species in the eucalyptol group had refractive indices ranging from 1·4686 to 1·4774 and the solubility was from 1·05 to 8 volumes 70% alcohol, down to No. 45, the remaining six being insoluble in 10 volumes. The specific gravities of the oils of this group were mostly above 0·91. The 7 pinene oils in which phellandrene was absent had refractive indices ranging from 1·4741 to 1·4788, and none were soluble in less than 7 volumes 80% alcohol. The pinene oils (14 species) in which the sesquiterpene was pronounced, and phellandrene absent, had refractive indices ranging from 1·4801 to 1·4948, while the oils which contained the aldehyde aromadendral in some quantity, and in which phellandrene was absent (9 species) had refractive indices from 1·4828 to 1·4946. The refractive indices of the phellandrene oils which contained piperitone (11 species) ranged from 1·4828 to 1·4945. The 22 phellandrene oils in which the sesquiterpene was a pronounced constituent had refractive indices ranging from 1·4801 to 1·5065. The perfumery oils as *E. citriodora*, *E. Macarthuri* and *E. Staigeriana* were not classified.

Remarks were made by Mr. W. A. Dixon, Mr. W. M. Hamlet, Dr. George Harker and Mr. G. H. Knibbs. The author replied.

Mr. Lenehan exhibited a chart illustrating Trans Pacific Longitude, and read a letter from Dr. Klotz in connection therewith.

Some remarks were made by Mr. Knibbs and the President.

## ABSTRACT OF PROCEEDINGS, SEPTEMBER 6, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, September 6th, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty-seven members were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. R. P. SELLORS and J. BROOKS were appointed Scrutineers, and Mr. W. M. HAMLET deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of one for the second time, and of three for the first time.

The following gentleman was duly elected an ordinary member of the Society. viz.:—

Taylor, John M., M.A., LL.B. (Syd.), North Sydney.

The Chairman announced that bound copies of the Society's Journal, Vol. XXXVIII., for 1904 could be had on application to the Assistant Secretary.

Thirty-two volumes, 243 parts, 20 reports, and 2 pamphlets, total 297, received as donations since the last meeting, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "Reinforced Concrete," Paper III., by Professor W. H. WARREN, Wh. Sc., M. Inst. C.E., M. Am Soc. C.E., Challis Professor of Engineering, University of Sydney.

The following matters were dealt with:—

*a*. The adhesion of cement mortar and concrete to steel.

*b*. The experimental determination of the neutral axis in a plain concrete, and also in a reinforced concrete beam, and the curves of strain for loads increasing from zero to

the load producing fracture; the determination of the true form of the stress curve from the actual strain curve in a plain and in a reinforced concrete beam.

*c.* The safe working stresses and the fundamental equations recommended for the design of reinforced concrete structure.

*d.* The adhesion of cement mortar and concrete to the steel reinforcement was determined by pulling out specially prepared bars of Bessemer steel from prisms 12 inches long × 4 inches × 4 inches cross section, by means of a testing machine.

| | |
|---|---|
| i. With steel bars having the natural skin on, after 45 days hardened in air ... ... ... ... | 198 ℔ per sq. inch |
| ii. With the skin removed and the bars polished, after 45 days hardened in air ... ... ... | 125 „ „ „ |
| iii. With the skin removed as in ii., but hardened in water, after 45 days ... ... ... ... | 185 „ „ „ |

*b.* The experimental determination of the neutral axis in a plain and in a reinforced concrete beam, also the curves of strain for loads increasing from zero to that necessary to produce fracture, was made in a special form of Buckton testing machine, with two hydraulic presses for applying the loads at the ends of the beams tested. Ten beams 72 inches long were tested on supports 40 inches centre to centre, with two overhanging portions each 16 inches long. The apparatus for measuring the lengthening and shortening of the beam between the supports over a length of 40 inches, consisted of eight Martens' mirror extensometers, with a corresponding number of scales and telescopes arranged at different positions in the depth of the beam. The extreme fibre strains were determined by

means of four Martens' sector extensometers, and the deflections with dials. The mirror extensometers read accurately to $\frac{1}{10000}$ of a millimeter, and it will be observed that the bending moments and corresponding stresses between the supports over a length of 40 inches are constant (neglecting the effect of the weight of the beam itself.) Four reinforced beams were exactly alike in composition, age, and reinforcement, and the mean deformations, which differed very slightly from the corresponding individual deformations, were plotted. The strain curves prove that a plane section before flexure is not a plane section after flexure, and that the deviation from the plane is greater as the bending moment increases. Again, the neutral axis moves from the centre of the beam towards the compression side as the bending moment increases. The stress curves determined from the strain curves are fairly straight for a bending moment of about one third of that producing fracture, but they are curved for greater bending moments approximating closely to parabolas just before fracture. The stress curves determined from the tests of the other reinforced concrete beams confirmed these results completely. In the plain concrete beam, without reinforcement, the strain curves were approximately straight lines, and the stress curves deduced from them were curved more on the tension than on the compression side, but in both they approximated closely to parabolic curves; the neutral axis also moved 0·8 of an inch towards the compression side as the bending moment was increased.

In regard to the application of these conclusions to the practical design of reinforced concrete structures, it appears desirable to neglect the tensile stress in the concrete, as it contributes little to the moment of resistance of the beams. The equations deduced in Paper II. do not

require any modification, but the following stresses are recommended in the design of reinforced concrete structure :—

| | |
|---|---|
| Extreme fibre stress in concrete in compression, $c$ ... = | 500 ℔ per sq. inch. |
| Shearing stress and adhesion of the concrete to the steel reinforcement ... ... = | 50 ,, ,, ,, |
| Direct compressive stress in columns ... ... ... = | 350 ,, ,, ,, |
| Tensile stress in steel reinforcements, $f_s$ ... ... ... = | 16,000 ,, ,, ,, |
| Compressive stress in steel reinforcements ... ... = | 12,000 ,, ,, ,, |
| Shearing stress in steel reinforcement ... ... = | 10,000 ,, ,, ,, |

Ratio of $\frac{E_s}{E_c} = 15.$

Fundamental equations in rectangular beams :—

$$\frac{cx}{2} = f_s p \quad (1)$$

$$\frac{c}{f_s} = \frac{E_c}{E_s}\left(\frac{x}{u - x}\right) \quad (2)$$

$$\frac{M}{bh^2} = f_s p \left(\frac{3u - x}{3}\right) \quad (3)$$

$$x = \sqrt{p^2\frac{E_s^2}{E_c^2} + 2pu\frac{E_s}{E_c}} - p\frac{E_s}{E_c} \quad (4)$$

Examples are given in the paper, also, of the application of the conclusions arrived at to tee shaped beams.

2. "The Occurrence of Inclusions of Basic Plutonic Rocks in a Dyke near Kiama," by C. A. Sussmilch, F.G.S.

The specimens described were obtained from the Bombo Quarries, about 2 miles north of Kiama, and consist of rounded fragments of basic and ultra-basic plutonic rocks embedded in a dyke rock. The following plutonic rocks

were described:—(1) Hypersthene Gabbro; (2) Augite Peridotite; (3) Enstatite Peridotite, containing Picotite; (4) Pyroxenite. The dyke rock was shown to be a monchiquite. The occurrence of these inclusions (xenoliths) taken in conjunction with those occurring at Bulli, Dundas and various localities in the Sydney District, points to the occurence of large areas of basic and ultrabasic plutonic rocks at some distance below the surface in this part of New South Wales.

### EXHIBITS.

Professor Warren read some notes on hardness of different metals, and exhibited a Sclerometer for testing same.

Mr. Lenehan exhibited and explained a chart showing drift of the s.s. "Pilbarra," after losing her propeller blades.

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## ABSTRACT OF PROCEEDINGS, OCTOBER 4, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, October 4th, 1905.

H. A. Lenehan, F.R.A.S., President, in the Chair.

Thirty-six members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. F. B. Guthrie and R. T. Baker were appointed Scrutineers, and Prof. Liversidge deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of three for the second time, and of one for the first time.

The following gentleman was duly elected an ordinary member of the Society, viz:—

SIMPSON. D. C., M. Inst. C.E.; North Sydney.

Three volumes, 118 parts, 4 reports and 2 pamphlets, total 127, received as donations since the last meeting, were laid upon the table and acknowledged.

The following note was read and explanatory remarks made upon the several exhibits shown:—

"Note on some simple Models for use in the Teaching of Elementary Crystallography," by W. G. WOOLNOUGH, D.Sc. [Communicated by Prof. T. W. E. DAVID, B.A., F.R.S.]

Dr. WOOLNOUGH exhibited models to illustrate the connection between the number of faces in a crystal "form" and the elements of symmetry of the group to which the crystal belongs. He explained briefly that all crystals are symmetrical bodies, the symmetry being due to a regular repetition of similar faces with respect to planes, axes, and a centre of symmetry. Planes of symmetry divide crystals into parts which bear the same relation to one another as an object and its reflection in a mirror. With respect to axes of symmetry, the repetition of faces is rotational in character. Planes of symmetry are therefore represented in the models by mirrors suitably arranged, and crystal faces by triangles of cardboard. The mirrors are so fixed that the multiple reflection of the card reproduces the shape of the most general form possible in the crystal group. In this way it is very strikingly shown that in the normal groups of the cubic, tetragonal, hexagonal, and rhombic systems are closed forms of 48, 16, 24

and 8 faces respectively. The model for the normal group of the monoclinic system consists of a mirror pierced by an axis capable of rotation, the cards representing faces are fixed in such a way as to show, by rotation of the axis through 180°, that the general form consists of four faces only, and is open. In the normal group of the triclinic system, where there is only a centre of symmetry, this is represented by a spherical cork, on opposite sides of which two equal and similar cards are carried showing that every form in this group is open and consists of two faces only.

Remarks were made by Prof. DAVID, Mr. S. H. BARRACLOUGH, and Mr. G. H. KNIBBS.

EXHIBITS.

Prof. LIVERSIDGE exhibited specimens of metallic calcium and described its preparation and physical properties. Some remarks were made by Mr. GUTHRIE.

Mr. J. H. MAIDEN exhibited and commented upon the following :—

1. The Thready-barked She Oak from Northern N.S.W. (*Casuarina inophloia*). Remarkable for the texture of its bark, its coarse medullary rays, and the uninflammable character of its wood.

2. Fresh male amenta of *Araucaria Rulei*, an interesting New Caledonian species which rarely produces male flowers in Sydney.

3. *Selaginella lepidophylla*, an American plant (Mexico to Perú, etc.) which, artificially scented with oil of cinnamon is at present being sold in Australia as the true "Rose of Jericho," which is a Crucifer from Palestine.

Some remarks were made by Mr. R. T. BAKER.

Mr. HENRY DEANE, M.A., M. Inst. C.E., exhibited a series of photographs of the Frank, (Alberta Territory, Canada)

Rock Slide of 29 April, 1903. See Report, Department of the Interior, Dominion of Canada. Extract from Part viii., Annual Report 1903, Ottawa, 1904 :—

1. Turtle Mountain, part of easterly range of Rocky Mountains.

2. Summit 3,000 feet above valley of Old Man River. Upper Palæozoic Limestone, above Cretaceous shales and sandstones below.

3. Slipping mass, one-half mile square, and probably 400 to 500 feet thick. It crossed the valley, rising to a height of 400 feet on the other side. Distance from summit to end of slide $2\frac{1}{2}$ miles. Area covered by débris 1·03 sq. m. Number of lives lost about 70.

Remarks were made by Prof. DAVID, Dr. WALTER SPENCER and Mr. G. H. HALLIGAN.

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## ABSTRACT OF PROCEEDINGS, NOVEMBER 1, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, November 1st, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty-five members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

His Honor Judge DOCKER and Mr. ALG. PEAKE were appointed Scrutineers, and Mr. HAMLET deputed to preside at the Ballot Box.

The certificates of three candidates were read for the third time, of one for the second time, and of five for the first time.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

BIGNOLD, HUGH BARON, Barrister-at-Law; Chambers, Wentworth Court, Elizabeth-street.

DAMPNEY, GERALD F., Fellow of the Society of Chemical Industry; "Doonbah," Hunter's Hill.

HYDE, ELLIS, Analyst; 27 York-street.

Thirty-three volumes, 191 parts, 24 reports, 7 pamphlets and 8 maps, total 263, received as donations since the last meeting, were laid upon the table and acknowledged.

Prof. LIVERSIDGE gave notice of motion that Rule XXVIII. be altered to read as follows:—

"Meetings of the Council of Management **may** take place on the last Wednesday in every month **or** on such other days as the Council may determine."

THE FOLLOWING PAPER WAS READ:

"Provisional Determination of Astronomical Refraction, from observations made with the Meridian Circle instrument of the Sydney Observatory," by C. J. MERFIELD, F.R.A.S., Mitglieder der Astronomischen Gesellschaft.

This paper gives the results of an investigation into astronomical refraction, deduced from some five hundred and fifty observations of forty fundamental stars taken with the meridian circle of the Sydney Observatory during the month of July 1905. The author fully explains the methods adopted in dealing with the observed data, showing its advantages and otherwise. Two examples of the adopted forms used in the reduction are given, by which the simplicity of the method is well illustrated. After completing the discussion of the data, the results are formed

into normals with the zenith distance as argument. An examination of these results clearly indicates that the so called constant of refraction needs, not only a correction, but one for every zenith distance. It may be remarked that similar conclusions have been obtained by recent investigators in this connection. From the results of this work the author arrives at a value of the constant

$$a = 60''\cdot 283$$

$$\text{for } B = 760 \text{ mm. at } 0\ (C) \text{ and } t = 0\ (C)$$

It would appear from this investigation, however, that the formula from which the refractions are computed requires modification. The formula may be retained unaltered and the desired result obtained by correcting the value of Log $a$ of the tables in a manner shewn in the paper. Thus we have $\quad \text{Log} \triangle a = +\ 0\cdot 000122\ [52^\circ\ 30'\ 33'' - z]$
in which $z$ equals the zenith distance in arc.

The conclusions arrived at by the author are as follows: That if observations of zenith distance of celestial objects are taken between limits of time separated by some hours, then greater accuracy in the reductions, to obtain correct positions, can be obtained by taking fully into consideration the fluctuations of the height of the barometer and especially the variation of the temperature, indicated by the readings of the thermometer, when computing the refractions for a series of observations extending over a period of several hours duration. Adopting a state of the atmosphere for a mean of the times of observation does not seem sufficient. Further, the refraction table, (Bessel), in use at the Sydney observatory would represent the observed refractions much better, if a correction be applied for the difference in the force of gravity at Greenwich and Sydney. This correction is represented by a very simple equation which is a function of the latitudes of the two places. The author also considers that the refractions

computed from the Pulkowa tables, after applying the gravity correction, would represent the observed values better than those of Bessel.

Remarks were made by Mr. KNIBBS and the President.

EXHIBITS.

Professor LIVERSIDGE exhibited plants of British Woad, *(Isatis tinctoria)* in flower and gave an account of woad and its uses, of which the following is an abstract:—*Isatis tinctoria* is a biennial herbaceous crucifer. The flowers are small, yellow, and borne in spreading clusters, or panicles. The leaves are large, smooth, and lanceolate or spathulate. The seeds from which the plants exhibited were grown, were sown in his garden in July or August last, and the plants are about 3 feet 6 inches high, and, although biennial, have been in flower for about a fortnight or three weeks. The seeds were obtained from Mr. Howard's Woad mill at Parson Drove about 6 miles from Wisbech, on August 20th, 1904, when Professor Liversidge was one of a party from the British Association meeting at Cambridge, visiting the woad mill and farm. The party were told that there was only one other woad farm left, viz: near Holbeach in Lincolnshire, and that one of the two (Parson Drove ?) was about to be relinquished and the land used for other purposes.

Woad is a native of South Europe, and before the introduction of indigo was very largely used as a blue dye and was extensively cultivated in various parts of Europe. According to Pliny, the ancient Britons used it for staining their skin blue. In England it was formerly cultivated in several places, but it is now only grown in two places, in the fen lands of Lincolnshire, and Cambridgeshire. It requires very good soil and the land fetches £10 an acre rent, and from £150 to £200 freehold. The seeds are sown in March or April, and the first crop of leaves is gathered

from near base of the plant in June, one or two more gatherings may be made at intervals of a month or six weeks. The freshly gathered leaves are at once ground to a pulp in roller mills (worked by horses) very similar to a clay mill, in a circular thatched shed, the rollers are slightly conical hollow wooden drums, fitted with 25 or 30 longitudinal iron bars to serve as the crushing edges, the pulp is removed and allowed to drain; when sufficiently dry, it is worked up into balls of about 4 inches to 6 inches diameter, by hand on a tray ('balling horse'). The hands of the women who worked the woad into balls were slightly stained blue. The balls are placed on gratings arranged in tiers in sheds ('ranges,') with open sides so as to allow free circulation of air. When the whole of the crop has been treated in this way the balls are ground to a coarse powder in the roller mill, which is spread over the floor of the 'couching house' to a depth of two or three feet, and worked up into a paste by frequently sprinkling with water and turning over with spades. This goes on for several weeks. During this process fermentation is set up; at first there is a considerable rise in temperature, the mass steams and an offensive smell is given off. The operation requires much care and some skill; if carried out too slowly the product is 'heavy' or sodden, and if too quickly 'foxy.' When the fermentation is over and the pasty mass has cooled down it is packed in casks for market. Nine parts of the leaves yield about 1 part of prepared woad and this may contain 2% of indigotin, but some samples contain none at all. A few years ago it fetched £25 a ton, it is now worth only £9.

It is not now used for the sake of the dye, but is employed to start fermentation in the indigo vat (or woad vat) used by the Yorkshire woollen dyer, and its use will, now that artificial indigo is coming into use, soon be given up altogether. Imitation woad is made from rhubarb, cabbage

and other leaves, but they are inferior in starting fermentation. Indican, the glucoside yielding indigo blue can be extracted from the dried woad leaves by ether, on washing this with water and evaporating the water solution the indican is left as a pale brown syrup, soluble in spirit, ether, etc. Indican is very unstable, boiling or long heating its solution decomposes it and it yields indiglucin but no indigotin, *i.e.*, indigo blue when treated with acids. To illustrate the process of dyeing with woad; digest half a pound of woad with a gallon of water, in a closed vessel, at 100° F., for 12 or more hours; then stir in about $\frac{1}{4}$ oz. of lime. The indican ($C_{26}H_{31}NO_{17}$) undergoes hydrolysis and indigo-white is formed. If now a skein of white wool be placed in the liquid for an hour or so, on taking it out and exposing it to the air it will acquire a pale blue colour; the soluble indigo-white hydrindigotin ($C_{16}H_{12}N_2O_2$) or reduced indigo is oxidised by the air to insoluble indigo-blue or indigotin ($C_{16}H_{10}N_2O_2$).

An interesting account of the preparation and use of woad from the pen of Dr. C. B. Plowright, will be found in "Nature" of 1st February, 1900.

Remarks were made by Mr. W. A. Dixon and Mr. Maiden.

The experiment with Dr. Quaife's Lantern Electric Lamp was unavoidably postponed.

Mr. S. Henry Barraclough exhibited the Tantalum Lamp with stereoscopic photographs of Clarke Maxwell's Thermodynamic surface.

Mr. H. A. Lenehan, showed various diagrams of modern astronomical instruments for eclipse observations.

## ABSTRACT OF PROCEEDINGS, DECEMBER 6, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, December 6th, 1905.

H. A. Lenehan, F.R.A.S., President, in the Chair.

Thirty members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Mr. T. F. Furber and Dr. F. H. Quaife were appointed Scrutineers, and Mr. D. Carment deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of five for the second time, and of one for the first time.

The following gentleman was duly elected an ordinary member of the Society. viz.:—

Scheidel, August, Ph.D., Union Club.

Mr. David Fell, C.A.A., M.L.A., and Mr. Ferdinand Bender, were appointed Honorary Auditors for the current year.

The President announced (1) that the Council recommended the election of the following gentlemen as Honorary Members of the Society:—

Emil Fischer, Professor of Chemistry, University, Berlin.

Stanislao Cannizzaro, Professor of Chemistry, Reale Università, Rome.

Daniel Oliver, LL.D., F.R.S., Emeritus Professor of Botany, University College, London.

The election was carried unanimously.

(2) The death of Captain F. W. Hutton, F.R.S., Curator, Canterbury Museum, Christchurch, New Zealand, elected Honorary Member 1888, Clarke Medallist 1891.

Professor Liversidge submitted an obituary notice of the deceased gentleman, and afterwards moved the following resolution, which was seconded by His Honor Judge Docker and carried unanimously :—

(*a*) "The members of the Royal Society of New South Wales learn with the deepest regret of the death of Captain Hutton, F.R.S., one of its Honorary Members, and they hereby place on record their high appreciation of Captain Hutton's great and life long services for the advancement of science."

(*b*) "That the above resolution be forwarded to the late Captain Hutton's family with an expression of this Society's deep sympathy with them in their bereavement."

Twenty-two volumes, 131 parts, 56 reports, 12 pamphlets and 8 maps, total 229, received as donations since the last meeting, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ :

1. "A method of separating the clay and sand in clay soils and those rich in organic matter," by L. Cohen, Chemical Laboratory, Department of Agriculture. (Communicated by F. B. Guthrie, F.I.C., F.C.S.)

The methods usually adopted for separating sand and clay in the analyses of soils involve boiling with water, with dilute alkali, pestling etc., before elutriation. These processes have with certain classes of soils produced unsatisfactory results. The deficiencies of these methods are more apparent in humus and clay soils, owing to the cohesive power of the organic matter present, the vegetable fibre (cellulose) exerting a binding effect on clay particles

and causing them to behave in the elutriator as if they were sand grains. In order to eliminate the fibre the author uses a solution of zinc chloride in hydrochloric acid (40% HCl) with gratifying results. A weighed quantity, 30 gm. of the soil is passed through a sieve containing 50 meshes to the inch, and the resulting fine soil boiled in about 100 cc. of the above solution for half an hour. The mass is then cooled, diluted, washed out into the elutriating vessel and the water allowed to flow through. When the overflow water is quite clear, the residue is washed out, dried on the water bath and weighed as sand. A peaty oil containing 22·7% of organic matter yielded 57% of sand by boiling with water alone as compared with 6·17% by the zinc chloride process. Microscopical examination proved the latter to be practically pure sand, while the former contained an overwhelming proportion of clay and vegetable matter. A comparative table is shown giving percentages of sand obtained on treatment with different reagents, from typical soils to which this method more particularly applies.

Remarks were made by Mr. F. B. Guthrie, Dr. R. Greig Smith, Mr. J. H. Maiden, Dr. Harker, and His Honor Judge Docker. Mr. Cohen replied.

2. "Latitude of the Sydney Observatory,"—appendix to a paper on the "Provisional Determination of Astronomical Refraction, from observations made with the Meridian Circle instrument of the Sydney Observatory," by C. J. Merfield, F.R.A.S., Mitglieder der Astronomischen Gesellschaft.

This paper contains determination of the latitude of the Sydney Meridian Circle instrument, deduced from zenith pairs used in a previous work, on astronomical refraction, recently communicated. The adopted latitude

$$\phi = -33^\circ\ 51'\ 41{\cdot}1''$$

depended on observations taken, by the Rev. W. Scott, M.A.,

during the month of June 1859. His subsequent determinations indicated that the value is numerically too small, and the present reduction supports this view, the mean latitude obtained being

$$\phi_0 = -33^\circ\ 51'\ 41{\cdot}55''$$

This is only a provisional value, but is probably accurate to $0{\cdot}25''$, an alteration in the accepted value is regarded as unwise until the question is more completely discussed. Local conditions, existing near each meridian circle, differ considerably at all observatories. The results of the meridian circle should be reduced having regard to local refraction determined with the instrument used. Similarly the latitude, used in transforming the observed zenith distances into declinations should also be determined by the same instrument. A definitive determination of the absolute mean latitude of the Sydney Observatory is a desideratum. Were it decided to undertake such work, the observations should be made at intervals extending over a long period, so that the data could also be used for an investigation of the variation of latitude. For this purpose the construction of an instrument specially for the object in view is advocated.

Remarks were made by Mr. Lenehan and Mr. T. F. Furber. Mr. Merfield replied.

3. "Sociology of Some Australian Tribes," by R. H. Mathews, L.S.

The author stated his opinion that among the social institutions of a primitive people there is none of greater interest and value to the anthropologist than the study of these social systems. He also expressed his conviction that neither "sexual promiscuity" nor "group marriage" have ever existed among the Australian aborigines. He further expressed the opinion that the divisions into phratries, groups and sections had not been deliberately made

with intent to regulate the relations of the sexes, but had been developed in accordance with surrounding circumstances and conditions of life.

Some remarks were made by Mr. R. HELMS.

4. "On an undescribed species of *Leptospermum* and its Essential Oil," by R. T. BAKER, F.L.S., Curator, and H. G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

"The Lemon-scented Leptospermum." The species described in this paper occurs in the North Coast District of New South Wales and the Southern Coast District of Queensland. It is a shrub attaining a height from 6 to 12 feet, with erect branches and small, lanceolate, ovate leaves; the flowers occurring in the axils of the leaves on the upper branchlets. The fruits measure about two to three lines in diameter. Its differentiation from described species is based on both morphological and chemical characters, although the former are alone sufficiently marked to warrant its specific rank. It may possibly in the past, have been confused with some of the varieties of *L. flavescens*, but apart from well marked taxonomic characters none of those species give a lemon-scented odour. The leaves and terminal branchlets of this plant yielded 0·227% of an essential oil containing a considerable amount of citral. This appears to be the first time that the oils of the *Leptospermums* have been investigated, and the indications for the previously described species are not commercially promising. However, other species will be worked as opportunity offers. The marked lemon odour given by the leaves when crushed appears to be characteristic of this species, and is an aid in its discrimination. Besides citral (35%) the oil contained dextro-rotatory pinene (25%), an alcohol considered to be geraniol (9·74%), an ester most probably geranyl-acetate (5·35%) and a sesquiterpene.

Citral is the only aldehyde present in the oil, as proved in several ways. The crude oil was soluble in an equal volume of 80% alcohol, but not in 10 volumes 70% alcohol; it had a specific gravity 0·8095 at 15° C., a refractive index 1·4903 at 16° C., and a rotation in a 100 mm. tube of 9·2 degrees to the right. The pinene, which on a final rectification, boiled between 155–157° C., had a specific gravity 0·8601 at 15° C., a refractive index 1·4706 at 20°, a rotation $a^{D} + 35{\cdot}5^{\circ}$, and gave a nitrosochloride melting at 103°. The purified citral obtained both from the crystalline bisulphite, and from the soluble compound, gave in both samples a refractive index 1·4913 at 20° a specific gravity 0·8937 at the same temperature; it had the odour of citral and also gave the naphthocinchoninic acid for that aldehyde. The non-aldehydic portion of the oil had a specific gravity 0·8866 at 20°, rotation +13·4° and refractive index 1·4855 at 22°. It was esterised in the usual way for the determination of the free alcohol. Limonene could not be detected, nor were either phellandrene or cineol present. The name proposed for the species is *L. Liversidgei.*

## EXHIBITS.

Portion of Lightning Conductor crushed by the discharge, exhibited by Mr. D. K. Clark, with note by Prof. J. A. Pollock and Mr. S. H. Barraclough.

Specimens of American timbers by Mr. R. T. Baker.

The following donations were laid upon the table and acknowledged:—

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(The Names of the Donors are in *Italics.*)

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PROCEEDINGS

# ENGINEERING SECTION.

# PROCEEDINGS OF THE ENGINEERING SECTION.

(IN ABSTRACT.)

*The First Meeting of the Section was held 28th June, 1905, at The University.*

Mr. S. H. BARRACLOUGH, in the Chair.

The principal business of the evening was the Chairman's address, which dealt mainly with the question of Technical and Industrial Education; afterwards the Chairman exhibited, by means of lantern slides, some very fine views of the principal educational and technical schools of Europe and Great Britain.

Mr. JOSEPH DAVIS, M. Inst. C.E., was then installed as Chairman for the current year, and in the course of a short address to the members, he alluded to the services rendered by Mr. BARRACLOUGH during the two years he occupied the position of Chairman of the Section.

The resignation of Mr. C. O. BURGE, M. Inst. C.E., as a member of committee and of the Section owing to his departure for England was received with deep regret.

*The Second Meeting was held at the Society's House, on 20th July, 1905.*

Mr. JOSEPH DAVIS in the Chair.

The discussion on the papers on Reinforced Concrete, read by Mr. GUMMOW and Prof. WARREN at the previous Session was entered upon and aroused a good deal of interest, there being present several visitors from other Societies. Messrs. ANDERSON (Hon. Sec. of the Institute of Architects), WALSH, W. E. COOK, C. E. CARDEW (a visitor from Burma),

the Chairman, and the Hon. Secretary, took part in the discussion.

The authors of the papers having replied, the meeting then terminated.

*The Third Meeting was held on the 20th September, 1905.*

Mr. JOSEPH DAVIS in the Chair.

Mr. HENRY DEANE read a very interesting paper entitled "Notes on a tour through America, Great Britain, and Europe," which was followed by a general discussion participated in by the Chairman and Messrs. P. ALLEN, G. HOSKINS and CARDEW.

The author having replied, the meeting then terminated.

*The Fourth Meeting was held on the 14th December, 1905.*

Mr. JOSEPH DAVIS in the Chair.

Mr. WHITCHURCH SEAVER, B.E., communicated a paper through Mr. W. E. COOK, on "The Storage and Regulation of Water for Irrigation Purposes," which by permission of the Chairman was read by the author.

A discussion followed in which Mr. MCKINNEY dealt with the question of movable weirs and various kinds of modules.

Mr. JAMES DAVIS, a visitor from Colorado, addressed the meeting by invitation of the Chairman, on the storage of water from an American's point of view.

Mssrs. SMAIL and CARDEW contributed to the discussion, and Mr. MCKAY moved that the paper be printed and that the discussion be adjourned until next meeting.

The Chairman expressed the thanks of the Section to Mr. SEAVER for a very useful and interesting paper.

The meeting stands adjourned until next Session.

J. HAYDON CARDEW, Hon. Sec.

# ANNUAL ADDRESS.

By S. H. BARRACLOUGH, B.E., M.M.E., Assoc. M. Inst. C.E.,
Chairman of the Engineering Section.

[*Delivered to the Engineering Section of the Royal Society of N. S. Wales, 27th July, 1905.*]

## SUMMARY.

Introductory—Progress of Section—Choice of a Subject for Address—Brief review of the past three or four years—Directions of engineering progress—Progress of educational reform—Commissioners' reports—Sir P. N. Russell's second gift to the University of Sydney—P. N. Russell Scholarships—A School of Architecture—Surveying—Reorganisation of the P. N. Russell School of Engineering—Future needs—Our position in relation to others—Extraordinary activity in other countries—Correspondence Schools—The late Dr. R. H. Thurston and the Sibley College of Engineering—American progress—The case of Germany—Japan's achievement—The virtue of war—"Sport for sport's sake"—The art of invention—National efficiency—The menace to England—The position of Australia—The urgent necessity for national training—Rational v. empirical methods in industry—Types of labour—Primary and secondary industries—Agricultural education—Education not a luxury—The limits of prudent expenditure—The Morill Land Act in America—The urgency of the question—Conclusion.

BEFORE vacating the Chair custom demands that I occupy your attention for a short time with some remarks of a general nature appropriate to the occasion. In the first place, I have to thank you most sincerely for the privilege of being allowed to serve the Engineering Section for a second year of office. It is needless to state that I do not

assume that the unusual course of re-electing the chairman for a further term of service was on account of any special merits of the holder of the office, still I cannot but be distinctly conscious of the honour you did me and of the cordial good feeling which prompted my re-election.

It is now two years since the Section decided to suspend its regular monthly meetings, and to try and concentrate the papers in two or three special sessions during the year. It must be confessed that it is still open to question whether the scheme has been a successful one or not. In some respects it undoubtedly has; the session dealing with Water Conservation and Irrigation excited a great deal of interest amongst members of the Society and others, and the fact of the extra copies of the papers read at that session having all been disposed of, some to distant parts of the world, makes it apparent that our discussion of the question was considered to be of value. We have this year to decide whether it will be better to continue the sessional idea, or to revert to regular monthly meetings. Probably no alteration in the method of holding meetings will entirely get rid of the difficulty of small audiences which at times besets our Society, and which to a greater or less degree is apparently felt by all other technical and scientific bodies in Australia. The real difficulty consists in the number of societies as compared with the limited number of citizens who take any direct interest in scientific and technical matters. Through the kindness of the secretaries of the various societies, I quote the following figures, giving the approximate membership of the institution and the average attendance at meetings in each case.

| Society. | Membership. | Approximate average attendance. |
|---|---|---|
| Royal Society of N. S. Wales ... ... | 345 | 35 |
| ,, (Engineering Section)... | 100 | 25 |
| Linnean Society of N. S. Wales ... ... | 110 | 23 |

| Society. | Membership. | Approximate average attendance. |
|---|---|---|
| N. S. Wales Engineering Association ... | 122 | 40 |
| Electrical Association of N. S. Wales ... | 92 | 40 |
| Institution of Surveyors ... ... ... | 230 | 15 |
| Institution of Architects ... ... ... | 105 | 15 |
| Sydney University Engineering Society... | 170 | 45 |

The total membership of these societies is considerable, but no one has yet been able to suggest a method by which their efforts should be more concentrated. We have a certain small consolation at any rate in knowing that the same difficulty besets many, even of the largest scientific societies in other parts of the world.

It is practically certain that we shall at least have one continuous session this year to deal with the subject of scientific and industrial education in Australia. This it was proposed to hold last year, but it seemed wiser to again postpone it until the publication of the Education Commisioners' Report on Technical Education, which it is expected will be ready in the course of a few weeks, the whole of it I am led to understand being now set up in type. The object of this session, in which it is hoped representatives of all other kindred associations will participate, will not be so much to discuss the general question of technical education as an endeavour to discover the proper conditions for industrial and scientific training in this country.

It was at first proposed that the remarks I address to you to-night should be in the nature of an introduction to this session. It has proved, however, more convenient to hold this special meeting for the election of officers and to inaugurate the work of the year, but you will naturally understand that owing to the interest I take in the subject of scientific and industrial education, part at least of my remarks will be concerned with that topic.

In preparing his address the Chairman has choice of several methods. Commonly the address takes the form of an historical summary of the directions of progress during the immediately preceding period. On looking back over the remarks of the Chairmen for the last three or four years, I find that for one reason or another this course has not been adopted, so that no such review has been published during that time. If I do not follow this plan it is not that the period of the few years just passed does not offer considerable temptation for an historical sketch of progress.

Although, doubtless, each generation is inclined to overestimate the value or importance of contemporary occurrences, yet it is hard to believe that even future historians will not regard the present period as one of distinct interest, and at least considerable importance. It has been a period of wars with their marked effect on trade and industry; it has witnessed the close of the struggle of the South African Republics against Great Britain, the last effort as it seemed of the old type of civilization against the new; and it has witnessed the beginning, and may we trust the almost ending of the titanic conflict between Russia and Japan, the first effort as it seems to some of the awakened eastern civilization against the western.

It has been a period of industrial war marked by the growth of gigantic trade trusts and monopolies on the one hand, and the each year more elaborate organization of labour on the other. In England it has witnessed what a few years ago would have seemed the astounding proposal to foster our industries by tariffs, and to threaten neighbouring nations with fiscal retaliation. In Australia it has been the period of early experience with federation, with its inevitable disappointments. It has witnessed sociological experiments on a large scale; the practical prohibition of immigration of industrial workers, the establishment of

compulsory courts of arbitration and the like. It has witnessed previously unexampled illustrations of "spirited public works policies" with other people's money, and sweeping retrenchment schemes when the money was gone. It has been a time of great activity and controversy in educational matters the wide world over and in Australia, and particularly this State, there has been set on foot a movement of vital significance in the direction of educational reform. Finally, it has been a period of marked development in engineering matters, one or two of which will merit slightly extended reference. A very casual examination of this long but still very partial list will show that any of the topics could with advantage be discussed by this Section, but it is only the last two items that time will allow me to mention.

### DIRECTIONS OF ENGINEERING PROGRESS.

The one development of a strictly engineering nature to which I will refer on this occasion is that of prime-movers, to which subject I had occasion to give some special attention during a recent short trip to Europe, and there are a few points of progress in this direction worthy of at least passing notice. Steam turbines have more than fulfilled their promise of a few years ago as rivals of the reciprocating steam engine, and it seems to be now the almost universal opinion that no further marked improvement in the older type of engine may be looked for, or indeed is desirable. We may regard for example the reciprocating engines of such a vessel as the N.D.L. Kaiser Wilhelm II. as being the crowning effort of the designer of this type. Indeed it is hard to imagine anything in its way more perfect than these machines.

A good deal has been hoped for from the use of the Binary Vapour Engine as extending the usefulness, and increasing the efficiency of the ordinary cylinder and piston type, by

utilizing through the instrumentality of a second substance the lower temperature ranges, which cannot be effectually worked through with steam as the agent on account of the great specific volume and low pressure of steam at such temperatures. The elaborate experiments by Professor Josse on an engine of comparatively large size, and which in the early part of the year I had an opportunity of inspecting at the Charlottenburg Technical School, have been everywhere watched with great interest. In this engine, as many of you are probably aware, the second working substance was sulphur dioxide, the waste heat from the steam engine proper being used to evaporate the $SO_2$ which was used as a working substance in a special cylinder. These experiments have now been concluded, but I found that as regards their application to new engines probably not so great a field is available as was at one time thought, as the margin of waste in the primary engine, to be saved in this fashion, is not so great in the modern steam engine as it was in the earlier ones, and hence there is not so valuable a return to be obtained as an offset to the increased complexity necessarily caused by the addition of a cylinder using a second vapour. It is thought, however, that there are many older reciprocating engines already in use of less than modern maximum efficiency which both in efficiency and output might be improved materially by the addition of the extra parts. A fresh set of experiments is about to be undertaken for the purpose of determining what advantage may result from the use of these additional appliances in connection with the waste heat from gas engines, and it is very possible that here a much more promising field is available.

For certain classes of work we may assume that the usual type of steam engine will still be largely used, but there can be no doubt that the steam turbine, in one of its now many

forms, is to be the popular steam engine of the immediate future. It is hard to imagine anything, apart say from a great catastrophe in connection with the new Atlantic liners recently launched with turbine engines—a catastrophe there is not the slightest reason to expect—that can prevent this result being achieved. The prompt introduction of the turbine steamer into the Australian coastal trade is a matter for gratification, and speaks much for the energy and enterprise of the company concerned. The well known turbine types of Parsons, De Laval, Curtis, Zoelly, Rateau, and Riedler-Stumpf, are now being developed in the hands of large companies or syndicates in England, America, and on the continent of Europe, and orders for immense horse-powers are being rapidly executed. In addition to these six types, there are a considerable number of others, perhaps not so well known, but doubtless in a few years the number of types in actual operation will be largely increased. In fact so anxious are the big engineering firms to build turbines, that in addition to manufacturing the better known descriptions on a royalty basis, any new, if promising design for a steam turbine receives very respectful consideration at their hands.

Meanwhile, it is obvious that the steam turbine is to find an active competitor in the shape of the large modern gas engine operated with cheap gas of various descriptions, and the recent introduction of the smaller suction-gas plants has made this a source of power which is very hard to excel from the point of view of economy and convenience. One such plant at least is in operation in Sydney at the works of Messrs. John Sands, and a large plant of a similar type is being installed in New Zealand. It is hoped in the near future to instal an experimental gas producer plant in the P. N. Russell Engineering School at the University, and doubtless also considerable activity in the same direc-

tion will be experienced in many parts of Australia during the next few years. An important application of large gas and oil engines will yet be found in marine engine work, and the question of the special problems in mechanical design for this purpose I found is now being seriously taken up in Germany. Both steam turbines and gas engines still suffer from the great mechanical defect of not being able to reverse. It is true that devices for producing reversal have been suggested in each case, but there is nothing to indicate that the problem has been satisfactorily solved. Meanwhile, it is worth noting that the gas turbine is distinctly looming in the future as the goal of the thermodynamic machine. One type at least of this machine is advertised on the market, and although there are many special difficulties in the way, many designers are working at them, and when the type is perfected and made reversible probably a fairly definite limit will be reached in the direction of apparatus for transforming heat into mechanical energy.

### EDUCATIONAL REFORM.

One need have no hesitation in saying that the most important topic, looked at in the broadest sense, to attract recent public attention is that of Educational Reform. This is not the time or place to discuss the general question in any detail, but one or two matters emerge which merit passing notice. There probably has been no period within recent times when so much consideration has been given to the question of education, and its proper organisation. All over the world the matter has been discussed with an amount of detail, and a persistency merited by its supreme importance. The most striking features in this connection in Australia have been the appointment of the Educational Commissioners, one of whom it is gratifying to note is a member of this Section, and the consequent improvement

in the public attitude towards educational subjects. This great improvement in the educational atmosphere is one, if not the most important result already achieved by the Commissioners, and is the only reply needed to the objection raised by some that no commission of inquiry was called for. One has but to compare the degree of interest now being evinced in educational matters, and the intelligence thereof, with that which characterised the public mind some three or four years ago to realise what a marked improvement has taken place. It was previously alleged that no Commission was necessary, as already there was to hand a sufficient amount of information on the educational methods of other countries in the published reports of previous inquiries both by the authorities here and in other parts of the world, but fortunately this erroneous view did not prevail, and the commissioners have vigorously attacked a task much more difficult than that of merely collecting information as to *what* other peoples are doing, viz.—of determining *why* they are doing it, and so endeavouring to discover what are the right methods for this country to adopt to meet its own particular needs. No scheme of education can be imported ready made, and wholesale, from even the best educated country in the world.

We may trust that one direct result of improvement in the educational atmosphere of the community is that we have once and for all got rid of the idea—"Ours is the best in the world." It had so long and so often been reiterated that Australia had little to learn and much to teach, in the matter of education, that one of the first steps necessary for real progress was to obtain such a view of the educational position of other nations that we should realise how very far indeed we were from occupying so enviable a position, and in this matter the commissioners have been distinctly successful.

The sections of their report at present published have created a widespread interest, and evoked much discussion. As was to be expected, the conclusions arrived at have not been unanimously accepted in every detail, but there can be no doubt as to the marked service which the commissioners have already rendered to the community. With the appearance of the third and final section of their report dealing with technical and industrial education, which I believe now is practically set up in type, it is not unreasonable to hope that a very genuine effort will be made towards putting the educational system of the community upon such a basis that in course of time will make us worthy to rank with the at present better educated nations of the world.

SIR P. N. RUSSELL'S SECOND GIFT TO THE UNIVERSITY.

It is most proper when recording recent educational developments in Australia, before a society such as this, which is directly interested in the engineering and industrial progress of the community, that I should refer to the recent gift by Sir Peter Nicol Russell of a second sum of £50,000, to be added to the original gift of the same amount, for the purpose of endowing the School of Engineering within the University of Sydney. In making this gift, Sir Peter has shown himself to be a patriot in the truest sense, for although now long resident out of Australia he is evidently far from forgetting the land in which he achieved such great success, and where for many years he was so honorably connected with the industrial development of the colony. He sets a worthy example which we can hope will be imitated by many others similarly circumstanced. His action is in striking contrast to that of some, who having found health and fortune in this part of the world have retired to selfishly enjoy their wealth in the Old Land, and to judge by their words and actions are unconscious of any responsibility towards a country which even

now supports them in affluence, but to whose interests they are apparently quite indifferent.[1]

## P. N. RUSSELL SCHOLARSHIPS.

One of the objects for which the money was given to the University was that of founding scholarships for the purpose of helping the youth in the workshop, or the technical college student of unusual ability to enter the University and obtain the advantages of an engineering education. It cannot be doubted that in the course of time these scholarships will be as well known and as highly valued in this community as are the Whitworth Scholarships in Great Britain. Three awards are made yearly, each of the value of £75 per year for four years, so that at any one time there will be twelve P. N. Russell Scholars attending the engineering lectures at the University. To maintain these scholarships requires the permanent investment of the large sum of from £20,000 to £25,000. The awards are made after examination, and only those candidates are eligible who have been engaged for at least three years in a workshop, or who have been one year in a workshop and have taken a two year's course at the Sydney Technical College, or who have followed the full three years' day course at the Technical College. It is doubtful, if taking all the circumstances of the case into consideration, more liberal encouragement is anywhere to be found for the enterprising and capable youth in the shops to obtain the advantages of a complete engineering education.

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[1] As these pages were going through the press news was received of the death of Sir Peter Nicol Russell. Although this is not the place to make a full reference to this sad event, yet the opportunity cannot be allowed to pass without giving expression to the universal regret with which the news was received, as well as of our respectful sympathy with Lady Russell in her bereavement. The name and memory of Sir Peter Russell must always be held in high and affectionate esteem in this country which his labours and generosity have done so much to benefit.

## A SCHOOL OF ARCHITECTURE.

One addition to the engineering department for which a great need exists is that of a properly organised school of architecture. At present a short course of lectures on building construction and the history of architecture is given to certain of the students, but neither at the University nor the Technical College, nor indeed in any part of Australia is a comprehensive scheme of instruction for men desiring to follow this great profession to be found. Nothing indicates the character and taste of the community more than its buildings, and these again in their turn react in the development of the taste of succeeding generations. Few things are more worth a people's while than to live in the "House Beautiful." I do not for a moment argue that we have not in Sydney many fine architectural examples, not only in some of the larger buildings, public and ecclesiastical, but also in the more limited sphere of house architecture. The community indeed has a good deal to be thankful for when it is remembered that practically no thorough and systematic attempt has been made to train the designers of these buildings. In the early days there were two or three men, whose names should never be forgotten, who left behind them public buildings which are monuments to their artistic skill and constructive ability; and the effect of these buildings in setting a standard cannot be over estimated in importance.

Succeeding these few masters came a number of men trained in the better established schools of the Old World, who did much to beautify the city, and their pupils are now, in many instances, ably supporting the best of the early traditions. But it must also for truth's sake be confessed that with this there is a woeful quantity of the worst kind of architecture to be seen in all directions, and it is folly to hope that, unless definite steps are some day

taken for the training of the architects of the future, the average of building can ever rise beyond the mediocre. At present it is greatly to be regretted that, side by side with buildings in the city evidencing the skill, taste and power of initiative of the designer, huge structures are erected—their very size making them monumental—which transgress almost every canon of art, architecture, and engineering.

While referring to matters architectural it will not be out of place to incidentally record the admiration which everyone interested in technical subjects must feel for the enterprise, no less than the skill evidenced by our confreres of the Institute of Architects in publishing their bi-monthly journal "Art and Architecture." Not only for its matter and illustrations, but even as an example of the printer's and publisher's art, it merits nothing but praise. One cannot but hope that it will have an increasingly liberal support, not merely from professional men, but from the general public.

## SURVEYING.

Another subject to which I am glad to see attention has several times of late been drawn, is that of instruction in surveying. This is a subject which peculiarly lends itself to systematic instruction such as may be organised in an engineering college, and it is hard to see that anything but good could result from the organisation of a complete course of training in that subject at the University. It is not of course possible to produce by any such curriculum a professional expert in surveying any more than in any other subject. Some subsequent experience would of course be necessary, but the naturally haphazard instruction obtained during pupilage has even less to recommend it in the case of so precise a subject as surveying than in engineering or architecture.

Some one perhaps may wish to remind me that, according to recent utterances of deputations to Cabinet Ministers published in the daily press, both these ancient and honorable professions appear to be going to suffer eclipse, and therefore any anxiety as to the training of architects and surveyors is quite superfluous; but one cannot but believe that such conditions are temporary, and that in a country like this both professions must have a great future before them.

### REORGANISATION OF THE P. N. RUSSELL SCHOOL.

The new gift has made it possible to effect a reorganisation of the school, with a corresponding increase in the efficiency of the instruction imparted. Several new lectureships have been instituted, and the courses of instruction have been largely developed. The equipment of the school is gradually being improved as opportunities occur and funds allow. The apparatus provided for the testing of materials was already fairly complete, and the facilities available in this important direction considering the size of the school, compare favorably with those of older institutions. In other directions, however, there are very obvious defects which it is hoped to at least partially remedy in the near future. In the subjects of mechanical and electrical engineering a great deal of lee-way has to be made up. For instance, in the important subjects of mechanical refrigeration (in the early development of which Australia played so important a part), compressed air machines, modern oil and gas engines, producer gas plants, and steam turbines, to mention only a few, the school has hitherto had no equipment of any kind, but a beginning is now being made to remedy these defects.

In this connection I should like to take the opportunity of mentioning the great kindness of Mr. C. A. MacDonald of the Hercules Ice Machine Company, in donating to the

school a complete refrigerating plant, which is now being installed and includes a steam driven ammonia machine and a small set of ice tanks and refrigeration chamber. In both America and Germany the large manufacturing firms have shown great generosity towards the engineering and technical schools in the matter of presenting them with typical examples of the products of their works. It is there recognised that this practice is to the benefit of both the firms and the Universities, the latter having the advantage for instructional purposes of modern types of machinery, while the former have the satisfaction of knowing that the students, who are to be the future engineers, are obtaining an intimate knowledge of the special virtues of their machines. Several other firms in the city have also been kind enough to lend pieces of machinery or apparatus for the instruction of the students, for longer or shorter periods.

## PROGRESS OF THE SCHOOL AND FUTURE NEEDS.

There have now passed through the Engineering School something over 150 graduates, and there are about 80 undergraduate students in engineering on the University roll. Notwithstanding the dullness of trade and the absence of many great engineering enterprises in the community the great majority of the graduates have obtained satisfactory employment, and a considerable number are occupying responsible positions. They are very widely scattered however as regards location, and the greater part of them are not occupied in New South Wales, for reasons which it is unnecessary here to elaborate.

Very much remains to be done. The most urgent need at the present moment is the new building, for the erection and equipment of which the State Government have agreed to contribute £25,000 in compliance with a stipulation made by Sir Peter Russell. Unfortunately, however, there seems

a delay in providing the money, and meanwhile the work of the school is greatly handicapped.

### OUR POSITION IN RELATION TO OTHERS.

After thus briefly noticing some of the signs of progress and movement in our local educational world, it is not out of place to remark that progress is a relative thing, and that the essential question is not, have we made an advance? but rather, has our rate of progression kept pace with that of other countries? And from this point of view the outlook is not so promising. A short visit to Europe a few months ago only served to emphasise to my mind the fact that in the matter of engineering and technical progress, and in industrial training we are distinctly falling back. One is impressed with the fact that there is

### EXTRAORDINARY ACTIVITY IN OTHER COUNTRIES.

Indeed, in noting the signs of progress in German institutions during the last two or three years one cannot help a slight feeling of depression on realising the almost impossibility, as it seems, of keeping our institutions proportionately abreast of theirs. Even England, although herself in not too enviable a position, is leaving us distinctly behind, which could not be said ten or twelve years ago; and in America it is almost impossible to keep oneself informed of the rate of progress, and of the colossal sums that are being invested in scientific and industrial training. I propose to attempt no sketch of this progress at present, but as indicating the very genuine interest which is taken in the subject I would like to call your attention to the fact, probably not known to all, that there is a society in America, of which I have the privilege of being a member, devoted entirely to the consideration of the one subject of the promotion of engineering and industrial education. This society has now published 12 annual volumes of papers and discussions, covering the whole field of education for

engineers and for industrial workers, and by means of special committees is engaged upon important inquiries in regard to professional education in directions in which there have been controversies.

### CORRESPONDENCE SCHOOLS.

As an indication of the extraordinary demand that exists for technical instruction of various kinds it is not inappropriate to instance the institutions known as *Correspondence Schools*, and this more especially as they have recently been introduced into Australia, and already have attracted a good deal of support, especially, I understand, from people in country districts who have not the advantage of a regular college in their neighbourhood. These schools have sprung up like magic in America during the past ten years, and although some refuse to regard them seriously, are now thought by many to be serving a great need. Whether they will remain in demand, or are only a passing phase of educational opportunity, may be questioned. Until other opportunities of acquiring a technical training become practically universal, however, the evidence is already clear that they will find a great work to do. The fact that a single one of these schools has now on its roll of students several hundred thousand names is the best possible proof of the great demand for technical education. These schools supply their students with specially prepared text-books and pamphlets, and have developed systematic methods of imparting instruction by correspondence—a system indeed organised to a pitch of elaborateness and efficiency that commands the admiration even of those who criticise the method.

### THE LATE DR. R. H. THURSTON AND SIBLEY COLLEGE.

As no earlier opportunity has occurred of mentioning it I cannot let the occasion pass when speaking of educational work without referring to the death which has taken place

during my term of office of my sincere friend, and one time instructor, Dr. R. H. Thurston, the Director for 18 years of the Sibley College of Engineering at Cornell University. Although probably not generally known to the public of this country, his name was a household word amongst engineers and educators in America and Europe, both as a professional man, and an expert in educational matters. He has not inappropriately been called the father of the modern engineering school. As a young man he passed through the engineering workshops, took an arts degree at the University, entered the Engineering Corps of the U.S. Navy, and served all through the Civil War; and afterwards occupied a chair in the Naval Academy until in 1870 he accepted the then rather novel Professorship of Mechanical Engineering in the Stevens Institute of Technology, where for 15 years he laboured in developing, what was for its time, an unusually efficient course of instruction. Indeed his syllabus of instruction of that early date is in many respects a model even for to-day.

In 1885 he was called to be the first director of the Sibley College of Mechanical Engineering at Cornell, and began, what he rightly felt to be, the great work of his life. Starting as it did from small beginnings, and a few dozen students, he had the great reward for his labours of seeing the College, with its now more than one thousand students and its splendidly differentiated courses of instruction, develope into what, even at the risk of being considered biassed, I cannot but describe as one of the finest pieces of organisation in engineering education in existence.

Amidst the multitudinous duties of so great an office, he had that highest of all arts of seeming and being always a friend to the many thousands of students who came under his care. Their wants always claimed his ready attention; their letters years after leaving college were always

promptly and sympathetically answered, and their interests were never forgotten. He died, suddenly, as I have occasion to remember, on his birthday and mine, as he sat in his study chair at Cornell. Fittingly enough the sum of £50,000 is being collected to erect a memorial laboratory for research in engineering to his memory, but such benefactors of his race as he, require no monument.

## SIBLEY COLLEGE.

This is not the place to discuss in detail the organisation of the Sibley College of Engineering, although on a fitting occasion few subjects might more usefully be considered. Perhaps if it needs any expression of commendation it may best be had by reminding you of the great success which the University of Birmingham in England is achieving, and which, as is unstintedly admitted, obtained its inspiration largely from Cornell and Sibley. Sibley College was one of the early departments of Cornell University to be established, and accorded well with the ideal of Ezra Cornell, the quaint, shrewd man of business, of rather the old type, who conceived the idea of founding a great and truly democratic University; and though perhaps it lacks a certain glamour that attaches to the older New England Colleges, such as Harvard and Yale, whose history goes back to the early Puritan days, yet from a fairly intimate knowledge of all three, I venture to think that nowhere is the democratic ideal of American education better illustrated than in the Cornell of to-day. The University begins to realise, at least in some degree, the hopes of its large minded founder, who remarked in words which sound, in their simplicity, plain, but which embody a very noble thought, "I would found here an institution where any person may receive instruction in any subject." "Cornell," said a well known English educator—Principal Fairbairn of Mansfield College, Oxford—"is an example of a University

adapted to the soil, bravely modern and industrial without ceasing to be ancient and classical, or philosophical and historical."

Before leaving this subject, there are two policies pursued by the authorities at Sibley College which must commend themselves to every engineer, and which I personally trust it may be possible some day to embody in our own University. They are two policies which aim at keeping the engineering department in close and intimate touch with the actual practice of the profession outside.

The first is, to have each year a carefully organised set of lectures delivered by experts in the different branches of the profession to the students attending the regular college courses. This practice has the double advantage of enabling the experts in the profession to obtain a sympathetic insight from time to time into the organisation and working of the school on the one hand, and on the other hand it allows the students to become acquainted, at least by sight and voice, with the leaders of the profession which they aspire to enter. The second policy, which has recently been brought into force, is to insist upon the necessity of professors and lecturers keeping in active touch with the practice of their profession, and for this purpose leave of absence is to be granted at fairly short intervals, for a year or even two years to the members of the staff for the purpose of enabling them to resume for a time their professional practice.

One of the chief competitors of the Sibley College as a place of training for engineers is the Massachusetts Institute of Technology in Boston, and it is worthy of note that this institution during the last few months has become amalgamated with the Applied Science Department of Harvard University, the ultimate aim doubtless being to attach the great school of engineering and technology,

which will thus result, to the Harvard University as one of its constituent parts. Both these institutions already were possessed of large endowments and were provided with an elaborate staff of instructors, and housed in splendid buildings, but as I learn from a letter received a week or two ago from a member of the Harvard staff, they are about to receive the first instalment of a huge bequest, which will almost immediately yield an income of £10,000 a year, and as various annuities lapse their income from this one source will finally reach the magnificent figure of £100,000 a year. In view of these circumstances it is proposed to abandon the present buildings of both institutions, and to erect a magnificent pile in a locality where more room is available. When this is done it will probably be the most perfect institution of its kind in America.

Yet another plan worthy of special note is the arrangement recently made by one or two American and German Universities for the interchange of professors for periods of a year at a time. Nothing could be more stimulating to all concerned than such a scheme.

### AMERICAN PROGRESS.

However it would be a hopeless task to attempt to enumerate, even in outline, the great achievements of the American schools during the last few years. They are now to be counted in very fact by the score, and set the British nation, and I think Australia in particular, an example which they should endeavour to emulate. It may be replied of course and with a certain amount of justice that America with her vast opportunities and immense natural resources cannot under ordinary circumstances avoid achieving large success. In a sense this is true. It is doubtful if ever before in the history of the world, man had such extraordinary opportunities for material good as in North America. As it has recently been put, and with

some justice—"Nowhere else on the face of the globe is there such a land. With a soil of exhaustless fertility if properly cultivated; with original forest resources sufficient to supply the world for centuries; with an almost infinite energy stored in the ample coal beds, and in the oil and gas deposits, which are almost co-extensive with their territorial limits; with the richest iron ores so plentiful and abundant as to make their value scarcely more than common rock or earth; with copper, lead, zinc, gold, and silver deposits in marvellous quantities; with a climate all that could be desired and nowhere equalled for agricultural purposes; and finally, but most of all, peopled by the most progressive races under the sun; with all these infinite opportunities, surely something should have been accomplished." But even admitting all this, it is a sorry argument that because natural opportunities are less, a people therefore is to be excused from making an equal effort. It has yet to be shown that this country is not possessed of as fine possibilities as America, and if, as is evident, the resources of the country are not quite so readily to hand as in the United States, it is surely all the stronger argument for a resolute and determined exploitation of those resources.

### THE CASE OF GERMANY.

No such argument, however, applies to the case of Germany, which during the last century, has shown how in the face of obstacles that a less courageous and wise people might have regarded as insuperable, a nation may bring itself from a position of apparent ruin to the very summit of international success. The history of this development has already several times been referred to in the recent educational discussions, so I will merely content myself with pointing out that within 12 years of the date of the Franco-Prussian War, a Royal Commission from England,

after a most careful study of the situation, reported that England had everything to fear and many things to learn from her new rival. "The situation," says a friendly critic, "becomes annually more acute and to-day England is realising the risk that she runs of losing possibly for ever her position as the leading manufacturing and commercial nation of Europe."

The explanation of this remarkable transition is deserving of the most careful study, and it is of peculiar interest to the members of this Society. As an American writer[1] has recently put it, "That an interior country like Germany, without a navy, and with little foreign commerce, could in a quarter of a century by increasing her manufacturing capacity tenfold make it equal to that of England; increase her shipping twenty-fold, making it second to that of England; effectually establish a regular export trade with every country on the globe, and by at once cheapening products and improving their quality, put herself in a position to hold these markets indefinitely; that all this could be accomplished in the face of open competition, and in this age of universal publicity, is indeed marvellous, and would alone prove that old methods have lost their potency and that something new has arisen under the sun."

### JAPAN'S ACHIEVEMENT.

But if the case of Germany is remarkable, what can be said of Japan which almost within the space of a single generation has progressed from mediævalism to modern civilization. However puzzled we may be by the spectacle, and however dubious as to the value of the civilization, it would be the worst folly to miss the obvious lesson of so extraordinary a national performance. It is in a very striking degree an illustration of deliberate adaptation of means to an end; of national organisation on a large scale,

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[1] Prof. Johnston, Vol. VI., Proc. Soc. Prom. Eng. Education.

and with unparalleled efficiency; and of a zealous loyalty and patriotism that no obstacle could thwart. To emphasise the spirit that animated these neighbours of ours in the North, I cannot refrain from quoting two remarks made by the Mikado, when in 1872 the government promulgated the complete scheme of education which was part of the plan that aimed at placing Japan in the first rank of civilised peoples. The Emperor said in words which are worthy of oft repetition :—"It is intended that henceforth education shall be so diffused that there may not be a village with an ignorant family, or a family with an ignorant member. Persons who have hitherto applied themselves to study have almost always looked to the Government for their expenses. This is an erroneous notion proceeding from long abuse, and every person shall henceforth endeavour to acquire knowledge by his own exertions." It is impossible to know which to admire most, the first sentiment or the last.

The long list of primary and high schools, technical and trade schools, colleges for medicine, for agriculture, and for veterinary science, for commerce, and for the fine arts; institutes for training teachers and technical instructors; and last, but not least, the great Universities of Japan testify to the zeal and success with which the task has been carried out. The result of the present war, even before its conclusion is reached, is only a fitting climax to such efforts by such a people.

### THE VIRTUE OF WAR.

It is Ruskin, I think, who points out that sometimes the blessings of war overbalance its curse. Indeed it is not hard to realise that there are worse things than war. Even making allowance for the colossal material waste, the hideous loss of life, and the almost unimaginable suffering, who could deny that the present war is a blessing to Russia,

giving her people as a whole an opportunity that might otherwise not have offered itself again for generations, of escaping from a tyrannical bondage and becoming actually the great nation they are potentially. And not less is it a benefit to Japan, testing her qualities, proving her powers, enlightening the minds of the people, and confirming them in the wisdom of their long preparation, and still further preparing them for their great destiny.

Further, will anyone lightly deny that looked at from a national point of view, one of the most bracing experiences that could befall us as a people would be the presence of an enemy at our gates. Nothing could more quickly reduce matters to the basis of a reality they at present lack. Nothing would more readily convince that large and possibly major section of the community whose ideal may be not unjustly stated in the motto, "Sport for Sport's sake," that especially in a democracy such as this, national success can be achieved only through the responsible and deliberate efforts of the citizens.

### THE ART OF INVENTION.

It may seem on casual consideration that it is a matter of small moment whether (so long as a worker perform his labour faithfully), he works with pleasure and zest in the task, or merely as a means to subsequent amusement, but this argument will not bear close examination. Professor Reuleaux, one of the greatest of all the German engineering educators, has shown in an admirable passage that the process of invention, and of industrial discovery is not, as is popularly supposed, a haphazard matter. Inventions rarely come as flashes of intuition or as accidents, but are the results of long cogitation and rumination, and this none the less so because the inventor subsequently is not himself always conscious of the various steps by which he arrived at the result. Now these processes of thought are

absolutely essential to industrial improvement and advancement, and if this zest for labour, this inspiration of toil is lacking in the worker of all grades (it applies to the highest as to the lowest) much progress cannot be looked for.

The British people have been, and are, great inventors. It was an Englishman—or at any rate a Scotchman—James Watt, who nearly one and a half centuries ago produced the steam engine in a practicable form; it took other nations half a century to get proper possession of it, so to speak, and to this fact our past material prosperity is to a considerable extent due. It is equally true that it was an Englishman—or at any rate an Irishman—who produced the steam turbine in a practicable form some 20 years ago, but in these days progress is fast, and not 10 years were required for other nations to have full possession of it. To-day, more Parsons steam turbines are built out of England than in it.

### NATIONAL EFFICIENCY.

The methods of the past will not serve. They were good, but something more efficient is now required. It was Lord Rosebery who in a remarkable speech a few years ago put this matter with great emphasis, and set forth the position that the vital question now confronting Great Britain was, whether she intended abandoning her ancient policy of "muddling along," and substituting for it that of "efficiency." National efficiency, the adaptation of means to ends, is what is lacking at present in our Nation. For the time Australia's prosperity, commercial and industrial, is largely bound up with that of Great Britain, and the important question for us is whether our methods display this quality of "efficiency." It would not be hard to establish the fact that at present they largely do not. Without going into such a discussion in detail, I think it is a fair comment to make that the three public Commissions

of Inquiry recently appointed, are somewhat striking evidences of the inefficiency of our method of doing things. I refer to the Cataract Dam Commission, the Lands Inquiry, and the recent Butter Commission. It would not be proper to-night to discuss anyone of these three, more especially as two of the matters are *sub judice*, but the fact of such inquiries being necessary cannot but demonstrate that in the three important directions of public works, land settlement, and commerce our system, regarded from the point of view of benefit to the State, lacks efficiency.

### THE MENACE TO ENGLAND.

I think it may be agreed that England has lately distinctly recognised the menace to her position, and is now bestirring herself with considerable vigour to meet the enemy. She has proposed two distinct lines of effort. The first is the improvement of her system of scientific and industrial training, which everyone will admit to be a sound and safe path. The second, is the proposal of a considerable section for retaliatory tariffs, which some may fear is a weapon of the boomerang order, but in any case is certainly not proper for discussion this evening. The evidences of an attempt to improve the educational system in England are many. For instance, the fact quoted by His Excellency, the State Governor, in a public speech the other evening, that the expenditure on technical education by the London County Council had increased during the last 10 years from only £4,500 a year to over £300,000 per annum is most striking; and I should also have liked to refer amongst others, to the splendid equipment and organisation of the Manchester School of Technology, and of the Birmingham University, both of which institutions are on the best modern lines, and in different directions.

### THE POSITION OF AUSTRALIA.

Meanwhile, what have we been doing here during recent years? One can only say we have been virtually standing

still for 10 years past. After the erection of the present Technical College buildings, the State seemed to have temporarily exhausted its efforts, and beyond a very small increase in the expenditure, and the loyal efforts made by the authorities and teaching staff of the Technical Colleges to improve the conditions here and there wherever the limited means at their disposal allowed, we have done little in the direction of planning a systematic scheme of instruction. At present it is only recording a fact of the case to state that there is no co-ordination between the various technical institutions, either with primary and secondary education on the one hand, or with the University on the other, nor yet with the industrial life of the community which technical education should foster and encourage. There has been no elaborate and consistent planning of means to this definite end, no adequate preparation for taking our right place, nor even for sufficiently defending ourselves in the industrial war of nations. That such a state of warfare exists it is impossible to deny. No friendly treaties can prevent it, nor is it easy to see how peace can be secured. The relations between civilised nations are much more primitive than between civilised individuals. It is not an army of soldiers that constitutes the real menace in these days, but the regiments of scientifically trained directors of industrial enterprise, the armies of intelligent mechanics and artizans.

Although all nations may, in the words of an ancient writer, "turn their swords into ploughshares, and their spears into pruning hooks," yet if the spirit of competition still remain, the weapons, even in their tranquil disguise, are just as formidable. The only defence in this kind of strife is to reply to action with action; to meet education with training, and excellence with yet more. "Captains of industry," says Carlyle, "are the true Fighters, henceforth recognisable

as the only true ones." The situation is complicated by the fact that there is dissension in the camp. There is discord in our midst when all should be united to meet the keen competition of other nations. Our efforts are largely negatived by our domestic quarrels. Class is opposed to class; labour is opposed to capital. We have monopolies on the one hand, attempts at State socialism on the other. Equality of opportunity is demanded by some; equality of reward required by others. In endeavouring to solve the problem of training a nation in the arts and industries, these difficulties must necessarily be taken into account. It is quite evident that 'Demos' for better or worse is in power, and that permanently. But properly interpreted this may be, and I think should be, regarded as a great ground for hopefulness. As a recent writer has put it—"In our modern democracy the nation has called out its last reserves, and its success or failure must depend upon the action of the great body of the citizens, and not upon any small class of them." Once this is realised the urgency of the proper taining of the great bulk of the people which must and should be in the direction of industrial enterprise, is only made more evident.

## THE URGENT NECESSITY FOR NATIONAL TRAINING.

The pressing necessity which should weigh upon the mind of every statesman, and every man in any public capacity, in fact upon every citizen should surely be this one of providing that adequate scientific and industrial training for the nation, which for convenience we commonly refer to as technical education. We at present have no systematic scheme for training the great bulk of the people for 'the sequel of their lives.' We have tacitly agreed with most other nations that apprenticeship is dead, and have virtually abandoned apprenticeship as a system, but have substituted nothing for it. We are right to assume that

apprenticeship as a system of instruction is no longer adequate to modern needs. "When industrial capacity rested wholly upon tradition and empirical knowledge, and upon manual skill, it was absolutely essential that artisans should obtain all this knowledge and skill as apprentices in the shops and mills as manual helpers, and as unintelligent copyists. But since nearly all processes of the artisan have now a scientific and rational basis, and the work is done by machines which are the embodiment of the highest type of human reason and understanding, and since the machines require an almost equally intelligent oversight and direction to produce their largest output, and furthermore, since the new discoveries of science require continued changes in materials and methods to keep abreast of the times and to hold the market, and entirely new industries are daily established, founded on some new discovery or invention, and since the demand no longer determines the supply, but new and improved supplies are constantly creating their own demands in all lines of industry, it is evident that the efficient direction of any industry to-day demands a very large amount of technical knowledge which cannot be learned at the bench or in the shops. While self education is always possible, the obstacles are commonly prohibitive, and at best the results are meagre and unsatisfactory."[1]

RATIONAL *versus* EMPIRICAL METHODS.

But it is necessary to substitute a rational system of instruction for an empirical one. The modern position is that scientific investigation is the basis of industry, and that systematic training of the workers is the proper method of extending and developing it. This in no way denies the value of experience, but it should be pointed out that experience is simply the experimental method

[1] Prof. J. B. Johnson.

applied in a haphazard and costly fashion. Much has been accomplished doubtless in the past by the trial-and-error method, but this must more and more give way to the modern and rational one.

All this is true, and only emphasises the necessity for adopting some better system than we have. There is indeed an added reason for us in Australia to amend our systems of training. In this country, whether it is expressed in so many words or not, a distinct ideal of a great section of the community is, that there shall be short hours of labour, high rates of pay, and a limited number of workers and a limited output by the workers. In so far as these desires imply a determination to prevent sweating and civilized slavery, and the maintenance of a decent average of living in the community, they must command the support of everyone, but it is obvious that these ends cannot be achieved by enactments of Parliament, or decisions of Industrial Courts. The only possible means of making such schemes practicable is an extremely high efficiency of the workers. This country in truth cannot afford to have unskilled labour in its midst. So obvious is this statement that it seems almost gratuitous to suggest it, but thus far no attempt has been made to put any such scheme into practice. The providing of an adequately efficient system of industrial, scientific, and technical training for every man and woman in the land, who cared to avail themselves of it, would seem to be a natural corollary of our national conditions and system of living. To use a very technical phrase, one would expect to find as a marked 'plank' in the programme of any party that assumed to legislate for the industrial workers of a community an insistance upon the steady and progressive organisation of such a system of national training. Personally, I should not be surprised to see this question obtrude itself actively into politics.

Lately, it is true, we have in this State—and we are to be congratulated on doing so—taken what may prove to be the first step in this direction by establishing the office of Director of Technical Education, and appointing thereto a man admirably fitted to reorganise and supervise such a system, but this is only the beginning. To instal and maintain the system will cost large sums of money, much larger than anything that has hitherto been provided. The great point which everyone interested in the matter should endeavour to make is that such expenditure should not be grudgingly allowed as if in deference to the clamour of a section of the community, but that it ought to be entered into with the whole hearted support of every enlightened citizen who desires that this people should gain and keep its rightful place in the community of nations.

To argue that the country cannot afford the expenditure necessary for such training, or to express doubts as to the ultimate result of such training, is as irrational as for a farmer to affirm that he cannot afford the wheat with which to sow his land, and has not the patience to wait for the crop.

### TYPES OF LABOUR.

In order to give precision to my concluding remarks it will be sufficiently satisfactory to divide the workers of the community into three clearly recognisable, although not sharply defined types, viz.:—

(*a*) The artisan type, merging gradually from the practically unskilled labourer through various types of skilled workers to

(*b*) The foreman type with opportunities and occasions for advancing to

(*c*) The professional and scientific type,

and this division holds satisfactorily both as regards the primary producers in the great primary industries, and the secondary or manufacturing industries.

There seems little room for doubt that a people constituted as we are, must and should develop first and principally our primary industries, and those secondary industries which are connected therewith, and to this end it would be definitely false economy to put any limit to the expenditure of any sum necessary for the attainment of this end. No good reason can be alleged why in the course of time, and very largely now, Australia should not be absolutely unexcelled in the world, not only for such fundamentally important products as wool, wheat and meat, but also for such staple commodities as sugar and wines, dairy produce and fruits, as well as for timbers and leather and the great minerals. That we are not at present in this satisfactory condition will be sufficiently evident to anyone who has carefully perused the reports of our commercial agents published in the press during the last two or three years.

## AGRICULTURAL EDUCATION.

In this connection it will not be out of place to refer to the Hawkesbury Agricultural College, in which, owing to having been examiner in mechanical subjects for a number of years, and to various visits to it, I naturally take a great interest. It is no detriment to the undoubtedly good work done by this institution—probably the best of its kind in Australia—and to the marked effect it has had on farming in the State, to say that it is far indeed from being what it should be in a country with such vast agricultural possibilities awaiting development as Australia, and such intricate problems needing solution. The usual course is limited to two years, and every alternate day is spent in actual field work. The time available for work within the college is thus limited to the equivalent of one year. The effects produced upon students, who often enter with a preliminary education of a not necessarily high order, can-

not be expected to compare with those obtained in, for instance, the best class of agricultural college in America, the course in which occupies four years, and in which very often a student is required either to have had experience in farm work before entering the college, or to obtain it during the vacations.

One further remark seems necessary, although I do not know if the statement will meet with the approval of either the one department concerned or the other, but I can see no sound reason why agricultural education should not be under the supervision of the Department of Public Instruction, and this more especially since it is proposed now to re-organise the scheme of technical instruction in this State. It would appear to be almost obvious that the expert knowledge necessary for the direction of such a fundamentally important educational institution is to be looked for rather in a department specially devoted to education than to any other. This would make it possible to co-ordinate the instruction given in the Sydney Technical College and the various country branches, with that to be had at the Hawkesbury College and the Experimental Stations. At present there appear to be several subjects that are taught in common at the two institutions, and there appears to be room for possible overlapping, and consequent inefficiency and lack of economy in the scheme of instruction from the point of view of the State. To have both under one department would also make possible the utilising of the country technical colleges for instruction in agriculture and mining, which would seem to be largely their proper sphere. Sound instruction in these matters must pay as a national concern. The highest class of instruction is not a luxury which can be limited, or even dispensed with when funds are low,—it is a national investment, the return from which it is hard to overestimate. Even

lavish expenditure towards this end is amply justified, quite as much so as for roads and bridges.

### THE LIMITS OF PRUDENT EXPENDITURE.

It would be a very interesting question for discussion as to what the limit of efficient expenditure for national education really is. How much in fact would it definitely pay a people to invest yearly in the training of all its members, and what are the conditions that set an economic limit to this expenditure? Without attempting to solve such a problem this evening, it is perfectly safe to say that much more can be economically expended than has yet been the case by even the most lavish nation. I would ask in all seriousness what would be the result if a country like England, specifically decided to invest £100,000,000 during the next ten years in the scientific and industrial training of her people? It may be replied that such a project is chimerical, and not worth discussing, but the essential reasonableness of the proposal is more apparent when compared with the spending of £250,000,000 in three years on a war, which however necessary, produced little direct commercial return, and could only be justified, as I believe it was justified, on other grounds. But is the case different with education? Is it not providing a people with ammunition much more effective than powder and shot both for attack and defence in the modern strife of nations?

### THE MORRIL LAND GRANT ACT.

The United States, alone, in its legislature seems to have conceived a scheme, if not precisely along the lines suggested at least with equal enterprise and large hearted courage. Few people would appear to be aware that in 1862 by the passing of the Morrill Land Act the United States Legislature made a colossal effort towards putting the industrial training of the nation on a permanent and liberal footing. They dedicated an area of over five hundred

millions of acres of State lands, from the sale of which there should be established a perpetual fund, "the interest of which shall be inviolably appropriated by each State which may take and claim the benefit of this Act, to the endowment, support, and maintenance of at least one college, where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to Agriculture and the Mechanic Arts, in such manner as the legislatures of the States may prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." The Act forbade the use of any portion of the aforesaid fund, or of the interest thereon, for the purchase, erection, or maintenance of any building or buildings; but the several States claiming and taking the benefit of the provisions of the Act were required, by legislative assent previously given, "to provide, within five years, not less than one college" for carrying out the purposes of the Act.

These Land Grant Colleges of the United States are the product of one of the grandest examples of statesmanlike legislation that the world has yet seen. "Like all great enterprises having for their purpose the benefit of the people by legislative enactments, this failed of complete success through the indifference and folly, and the absolute stupidity of many of those public servants to whom its operation was entrusted; it has, nevertheless, produced incalculable good, both directly in the foundation and partial support of technical education, and also partly through its influence upon the States, inducing them to take up and carry on the work from the point at which the General Government left it."[1] Since the passage of the Morrill Land Grant Act in 1862 there has been a steady

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[1] Prof. R. H. Thurston.

development in America of the system of State Universities as the apex of the educational pyramid, and also in the lower planes, of more general and effective support of primary and secondary education.

### THE URGENCY OF THE QUESTION.

In the foregoing discussion I have avoided details; these we can consider later at the conference on scientific and industrial education, which it is proposed to hold shortly, and from which I trust some very definite results will follow. I have ventured to put these suggestions before you as I am profoundly convinced that the question of the systematic training of the great bulk of the people in the industries, arts, and crafts suitable to this land is from an economic point of view the most urgent and imperative consideration of the time. This is a matter that cannot be accomplished in a day or a year, nor indeed many years, but our national happiness and prosperity depend largely upon the efforts we make to achieve this end. It is one of the duties of a Society such as this, and of all the other kindred institutions to endeavour to stimulate and to guide public opinion on these questions.

Before concluding, and in order to prevent misunderstanding, there is perhaps one further remark I should make. It may have appeared that I have described technical and industrial education from a purely utilitarian point of view, and not from the general educational standpoint, but I should like to make it very clear that in my opinion technical education is infinitely more than a preparation for the earning of bread and butter; in fact as regards its effect on character, I venture to think that in a great many cases it may be more truly educative than much that is popularly so described. Technical education begins essentially in the Kindergarten, where the mind of the child is tempted out as it were, it is continued in any

proper system of primary education in which the faculties rather than the memory of the boy or girl are evolved, and in its later aspects of definite training for a trade or industry it developes the mind, and should ennoble the character. A man who has been so trained that he has a zest for his work apart from what reward he obtains for it, and who realises his obligations as a producer in the State, and whose experience with men and the concrete things of life has made him conscious of his own responsibilities and the rights of others has received the best of educations.

It now only remains to me to express again my very genuine appreciation of your cordial co-operation for the two years during which I have been privileged to serve as your Chairman, a service, the deficiencies of which none can realise more keenly than I do, and to welcome on your behalf my distinguished successor, under whose experienced guidance the Engineering Section is assured of an interesting and permanently valuable session.

# Some Notes on the STORAGE and REGULATION of WATER for IRRIGATION PURPOSES.

By T. Whitchurch Seaver, B.E.

[Communicated by W. E. Cooke, M.E.]

[*Read before the Engineering Section of the Royal Society of N. S. Wales, December 14, 1905.*]

The more general and popular questions of Water Conservation and Irrigation, have of late years been much discussed, and from the valuable information which has been collected, with reference to river discharges, location of irrigable areas, and so forth, a clear insight into the whole matter may be obtained. Some time ago several valuable papers were read before this Section, upon such subjects as the equitable distribution of water, property in water, and the chemical nature of soils, besides one which gave a general review of the progress of water conservation in this State. The authors showed that a large amount of water, which, being drained from our own catchment areas, was the sole property of this State, and now running to waste, should be conserved and distributed, and they indicated how this could be done, by the construction of storage reservoirs and diversion channels.

All water conservation and irrigation works may be classed under two general headings of :—

1. Storage. 2. Regulation.

Of these the first may be divided into :—*a* Run-off; *b* Main Storages; *c* River Storages; and the second into works connected with the :—*e* Controlling; *f* Raising; and *g* Conveying of the water.

Even amongst those whose business it is to deal with such matters, it may be doubted if the enormous waste of

our river waters is fully appreciated. Two-sevenths of the waste flow of the Murrumbidgee, said Sir Samuel McCaughey, would irrigate $2\frac{1}{4}$ million acres of cereals, which in his opinion would give a return of nearly £9,000,000. In the County of Cumberland alone, if the water now allowed to run to waste was fully utilized in growing fruit and vegetables, the amount of almost £700,000 now sent out of the State for the purchase of these commodities would be saved.

The most important matter in connection with storage works is of course the run-off from the catchment area, or rather, the amount of water that can be drawn from the reservoir, which will of course, be equal to the inflow, less the loss from soakage and evaporation. Roughly speaking, we may assume that 20% of the rainfall will find its way into the reservoir, and that the annual loss will be equal to about 7 feet off its top surface.

As an example of an extremely small run off, I may mention that at the Junee Storage dam with an annual rainfall of 27 inches, falling on a slate rock catchment of 1,500 acres, there seems to have been only $\frac{1}{200}$ part delivered into the storage reservoir. In fact the supply has proved so bad, that I understand, a second reservoir is to be constructed. That this run off is abnormally small, will be seen if we compare it with the following case : At Nagpur in the Central provinces of India a tank catchment was $6\frac{1}{2}$ square miles of low basalt hills, a fall of $2\frac{1}{4}$ inches took place in 80 minutes during one month of June, and no flow took place, the total rainfall for that month was $6\frac{3}{4}$ inches, of which what was considered to be the remarkably small flow of $\frac{1}{15}$ part flowed off.

In the Deccan district of India the rainfall being much the same as Junee, and the nature of the catchment no better, 114 observations of the run off into tanks were made and the following results tabulated, on :—

| | | |
|---|---|---|
| 26 occasions the flow was less than | 10 | per cent. of the rainfall. |
| 44 ,, ,, ,, between 10 and | 20 | |
| 25 ,, ,, ,, ,, 20 and | 30 | |
| 19 ,, ,, ,, above | 30 | |

## Storage Dams.

Storage dams are of two kinds, still water dams which are designed to hold water up to a fixed level, and overshot dams, which are designed to permit of flood waters passing over their crests. In the former, the exact and definite strains, at least from outside sources—for there are unknown strains in the dam itself—can be calculated and located, but in the latter, by reason of the varying strains set up by the falling water, the profile cannot be drawn according to any fixed rules. The truth of this is well exemplified by the case of the Gin Gin Weir on the Macquarie River above Warren, which, constructed with the profile of a still water dam, failed as an overshot dam by breaking across, at a depth of about 20 feet from its crest.

Now, it is not the dams which stand, but those which fail, that teach engineers the lessons they are most anxious to learn, and happily failures have been rare, when however they do occur, an inquiry into the cause of their downfall would furnish valuable information. The failure in this case may have been from an inherent weakness in the concrete, or from the design of the profile, or from the lifting power of the water which might have penetrated its face. I do not know, but any information on this important subject will I am sure be appreciated by our engineers.

In the ordinary calculations connected with the design of masonry dams, we assume in the first place that the foundations shall be solid and homogeneous rock, and in the second place that the dam when completed shall be an absolutely rigid structure, we then proceed to carry out the design in connection with the following conditions :—

1. That the horizontal thrust of the water, must be held back by the resistance of the masonry to sliding forward or overturning.

2. That the pressure sustained by the masonry or the foundations must never exceed a certain fixed limit, usually from about 140 to 200 lbs. per square inch.

3. That by causing the resultant of the forces to fall within the middle third of the base, there shall be no tension in any part of the structure.

In a new theory of dam strains recently formulated by Mr. Atcherley and Professor Pearson, both of University College, London, they join issue in many of these points. They say that neither the foundation or the dam can be considered absolutely rigid, that other forces are at work in the body of the dam and in the foundation owing to the elasticity of the materials and other causes besides those of water pressure and weight, that there is tension in the front of the dam, even though the resultant falls within the middle third, and lastly that the stresses in the vertical sections are more critical for stability than those in the horizontal sections. They maintain "that the current treatment of dams is fallacious, for it entirely screens the real source of weakness, viz. in the first place the tension, and in the second place the substantial shear in the vertical sections."

This theory being so much opposed to all former practice, might be considered as out of the range of practical constructive engineering, were it not for the effect it had in postponing the raising of the Assouan Dam.

Sir Benjamin Baker in his report on this subject, writes thus:—" I have arrived at the definite conclusion that still further experience of the working of the dam is required, before any responsible engineer, knowing the recent

advances in science with regard to the stresses on dams, would venture to state with confidence how much the water might be raised in the reservoir."

Sir William Garstin, Adviser to the Egyptian Ministry on Public Works, writes as follows:—"Eventually it is to be supposed that specialists will arrive at a conclusion upon this most important theory, which affects all existing dams, and which must influence all future designs for such works."

The whole subject is of course very abstruse, and can only be shortly referred to here, leaving it to be amplified by the discussion upon it, which must sooner or later take place. A good idea of the matter may however be obtained if we lay a number of books on top of each other to represent a dam, cut (theoretically) into horizontal layers. Now, according to former dam practice, if these books cannot be pushed asunder, nor the combined books turned over, they will represent a stable dam. The new theory says, turn the books on their edges, when this combined book dam may fail first by a lifting of their lower edges at the sides nearest the applied force and then by the resistance to shearing, or the friction between the books being overcome when they will fall down.

It may be stated in mathematical form as follows: The differential equation for dam strains can be made to consist of two parts, viz.

Tensional or pressural stress $= p_1 + p_2$

Shearing stress $= S_1 + S_2$

when $p_1$ = pressure, as the strain varies, according to its distance from the neutral axis

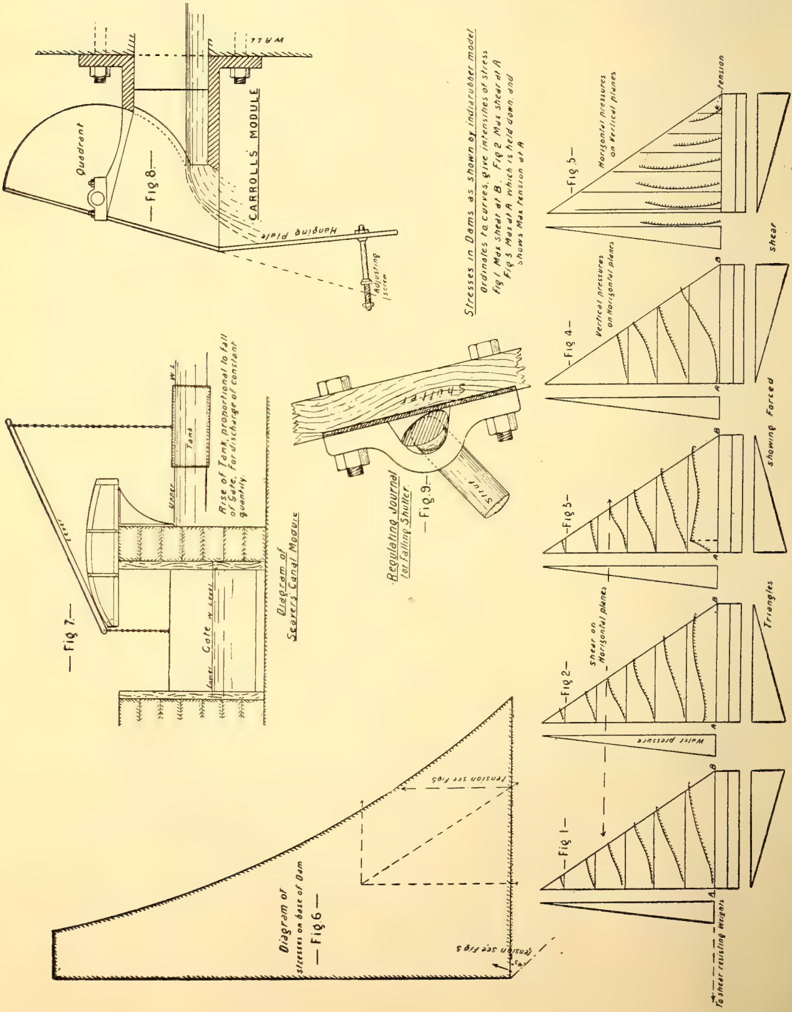
$p_1$ = certain additional strains of positive or negative magnitudes

$S_1$ = the parabolic distribution of stress

$S_2$ = certain additional stresses of positive or negative magnitude

If the height is great compared with the base, $p_2$ and $S_2$ may be neglected, and the stress is parabolic.

But, says Professor Pearson, $p_2$ does not $= 0$ as we do not know what these internal pressures may be, and if to the parabola or triangle of pressures, we add any system of equilibrated pressures, then the outside pressure remains the same but the internal stresses will be changed. He therefore sums up thus :— (See Fig. 6.)



*a*. There is the tension at the tail of dams, but it is not of first class importance, because

*b*. The tension in the substructure is much greater than in the tail, and the substructure, not the dam, is the weakest part.

*c*. Rupture will take along a line drawn from the tail at an angle of 45° towards the toe.

*d*. The shear in the base is neither triangular nor parabolic, but is maximum towards the front of the dam, minimum towards the centre, with a second maximum towards the toe.

As I understand it, the shearing alluded to may sometimes be rather a crushing by shearing, as when a short stone column fails by sliding taking place along a single plane surface or an angle of about 45° with its sides.

As regards the vertical shearing strains it would seem that the critical section is through the point where the resultant cuts the base, as it is at this point that the dam would tend to overturn, supposing the support of the toe was removed. That is to say, the support afforded by the toe might equally well be afforded by means of a chain attached to the base of the dam at this point and fastened to a point vertically above it. If the face of the dam were lifted it would overturn either by the breaking of this chain, that is by the masonry shearing or by turning over on the toe.

Some very interesting experiments on a dam profile constructed of thick indiarubber, have been carried out by Messrs. Wilson and Gore, which generally prove the statements made by Messrs. Atcherley and Pearson. The rubber was ruled into squares, each of which was strained by means of weights of the correct calculated amounts representing the water pressure, the weights of the dam

sections and the shearing forces along the base. The lines were photographed before and after the weights were applied, and the distortion of the angles in the latter case showed the amounts of the stresses. The total shear resisting weights were equal to the total water resisting weights, but the former could be adjusted so as to give a maximum shear either at the front or at the toe of the dam, and it was found that if the front of the dam was kept down and the maximum shear resisting force applied there, there was a maximum lifting tendency and also a shearing force near the toe.—(Figs. 1 to 5.) The shear along each horizontal section increased gradually towards the toe, but as a vertical section would cut several of these maximum shears, the failure would be more likely to occur in such a section than in a horizontal one. A full account of these experiments is given in *Engineering* for August 4th, 1905.

In this connection it is interesting to note that the length of the vertical section referred to is in Weigmann's Practical profile equal to $\frac{1}{8}$ of the height; in the Furens dam in France, which has its water face curved, $\frac{1}{2}$ of the height; and in the great Perrier dam in India, one of the few in which the curve of the toe is upward, also $\frac{1}{2}$ of the height. So that these two forms of profiles would seem to be the best for the resistance of vertical strains.

A great source of danger in a dam may arise from the porosity of the masonry or concrete, which under a head of say 150 feet, will give rise to an upward hydrostatic pressure of about 65lbs. on the square inch. In some of the more recent German dams provision is made for the free escape of any such water by means of agricultural drain pipes embedded in the concrete which carry it to the back of the dam. It is however along the foundations that such percolation is most likely to take place, as either the joint between the concrete and the rock may be bad,

or else fissures may occur in the latter; and as it is here that tension seems to exist, it is evident that any lifting force must increase the shearing strains in the vertical sections near the toe.

It will be remembered that a diversity of opinion took place as to the necessity or otherwise for cutting a gullet along the foundations of the Cataract dam, which, when filled with a tongue of concrete, would stop any possible percolation, and it may be of interest to point out what has been done in this respect in the case of two recent American dams. The Boonton dam at Jersey City is 114 feet high, with foundations of shale and sandstone, trenched to sound rock, in which was excavated a gullet 8 feet wide and 15 feet deep, afterwards filled with concrete.

At Wachusset Dam, Boston, there was 30 feet of excavation to schist and granite, which was further excavated for the body of the dam to a further depth of 13 feet, below which was cut a trench 20 feet wide and 14 feet deep to receive the concrete tongue. It would seem therefore, that although in the Cataract dam such a cut off trench might possibly be unnecessary, yet in view of the enormous interests involved, not the slightest risk should be taken.

When concrete is used in the construction of storage dams, it should not be rammed in the ordinary way, with heavy broad faced rammers, as such ramming will only consolidate the top surface to the depth of a few inches. To ensure solid work the mortar should be puddled round each stone by means of blunt spades or other similar tools, so as to leave no cavities. In the construction of the Boonton dam light rammers were used to "joggle" the stones to ensure the concrete flowing into all the cracks and crevices, and at the Bhatgarh Dam it was specified that the concrete was to be carefully worked up with stakes.

In the ordinary specifications for concrete, the measured amounts of the materials are stated, but it may happen in some cases that the quantity of mortar is not sufficient to fill the voids in the aggregate. This subject is thoroughly discussed by Lieut. Sankey, R.E., in *Engineering* for September last; he proposes the following as a specification for concrete:—"The percentage of voids in the selected aggregate is to be found, and sand and cement are to be added to make sufficient cement mortar of the quality $x$ sand to 1 cement to fill the voids + 20%."

One point to which I should like to draw special attention is that of the grading of sand for concrete purposes; this is already done in the manufacture of concrete pipes, some of which, with sides only $1\frac{3}{8}$ inch thick, will permit of no leakage under a head of 140 feet. From experiments made by Trautwine it appears that ordinary pure sand from the sea shore weighed 97lbs. per cubic foot, and its voids were 0·41 of the whole. Some very fine sand weighed 82lbs. per cubic foot, and the voids amounted to 0·5 of the mass. From the above we learn that coarse grained sand should be used for making concrete, if however, we mix both together, the voids disappear and the weight increases, from which it follows that the amount of cement can be reduced.

Some interesting experiments were made as to sand grading in concrete by F. Latham, M. Inst. C.E., during the last year, and were referred to by him in a paper read before the Society of Engineers in London. These tests were made in connection with the Penzance sea wall and from the materials used ten briquettes were made. In some cases, the materials were carefully measured according to the stereotyped specifications 1 of cement to 4 of sand &c., and in others care and judgment were used placing a little finer sand to the mixture and a larger pro-

portion of sand to fill up the voids in the gravel, and briquettes made of 1 of cement to 7 of aggregate. The result was that the 1 to 7 briquette stood 115lbs tensile strain and the stereotyped mixing of 1 to 4 but 45lbs. after 21 days immersion in water in each case. It was also noted that there was an appearance of excess of cement showing on the trowelled surface of the former and insufficient cement in the latter, although the proportions in which the cement was actually used were the reverse.

These large masonry dams, the construction of which has just been discussed, are for the storage of large bodies of water at the heads of our rivers. The necessity for such works may be taken as an axiom, and it is not possible, without them, to carry out irrigation sections on any but the smallest scale.

When however, water has been stored it can only be rendered available for irrigation purposes, either by raising its level and so permitting it to flow over the surface of the ground or by pumping it over the banks of the river. The main diversion weir at the head of a canal system must be a fixed structure of sufficient height to turn the required flow down the cuttings under normal conditions. In cases of low river discharge, when little or no water can be spared, the flow down these cuttings must be controlled by means of regulating gates. Weirs which are to be used in connection with pumping plants may either be fixed or movable, if the former, they must be of such a height that they will raise the water level sufficiently and also conserve a good supply, and at the same time not so high as to prevent a small flow from passing down the river. To fulfil both of these conditions they should be, say 6 feet high, with a movable crest of "drop boards" by means of which its height may be increased by say, 4 feet. A small rise will then fill each storage and pass

on to next, and when it has reached a certain fixed distance, the "drop boards" may be put in and the full depth of water conserved.

In cases, in which it is advisable to have the means of removing the whole structure, and so give a clear waterway, some form of falling gates must be used. The oldest of these weirs, that known as the Bear Trap was first erected by Josiah White in 1818 across the Lehigh River in Pennsylvannia, and consisted of two gates, the lower of which acted as a strut for the upper, being raised by admitting water beneath it by means of a valve.

In 1834 weirs formed of long timbers, known as "needles," resting at their lower ends against a sill, and at their upper ends against an iron framework were first erected by M.M. Poireé and Chanoine. This weir was afterwards improved by M. Cameré who substituted for the vertical needles horizontal boards hinged together, and which could be rolled up like a curtain.

The next important invention in connection with these works was that of movable shutters by M. Thènard in 1837. This form of weir, which has been used to a considerable extent in India, consists of two gates close together and hinged to the floor. The upper gate falls up stream and is raised by the force of the water, being held back by chains when it is up, the lower gate is raised and kept in position by means of a strut. This later gate now takes all the water pressure, when the upper gate can be lowered to its first position. This weir was defective, in that the great shock received by the sudden raising of the upper gate, often caused the chains to break, or the floor to be pulled up; to remedy this Lieut. Fernacres made use of an ingenious telescopic strut to be used instead of the holding back chains. As the gate is raised the piston of this strut is pushed into a cylinder, the water in which is forced out

through a small hole, so that the effect of the shock is lost and the gate comes to rest quickly.

An altogether new style of movable weir, and the best in use at the present time, was introduced in 1852 by M. Chanoine. This gate consists of a shutter turning on a horizontal axis, forming the top of a trestle, which is hinged to the floor; a strut hinged to the same axis supports the gate when raised. The bottom of this strut rests in a cast iron shoe out of which it can be pulled, when it is necessary to lower the gate horizontally on the floor. A weir of this description has been in use for some years across the Darling river at Bourke, where however the cumbersome "tripping bar" by means of which in the French weirs, the strut was pulled out of the shoe is replaced by a simple device, by means of which the raising and the lowering of the shutters are both effected in a very simple manner. When a shutter is to be raised it is pulled forward till the strut falls into the shoe, and if it is to be lowered the gate is pulled a little more forward, dragging the end of the strut up an inclined plane which is cut away at an angle of 45° in plan, so that when the strut falls over its top it has nothing to support it and so slides down a guide with the shutter folding over it.

One great defect in the action of these weirs is that often when the shutters have tipped over, they will not right themselves till the water level has fallen very much, and so reduced the storage capacity by a large extent. In the case of partly fixed weirs, this difficulty was overcome by M. Chaubart when he designed his self regulating gate. This gate, instead of turning on a trunnion joint, is supported by a pair of sectors which roll on horizontal planes, chains or links being used to keep them in position. As the shutter becomes more and more inclined so does the point of support move proportionally upward, so that it is always in equilibrium.

The author has designed a joint, by means of which the above advantage can be secured in connection with gates of the Chanoine type by forming the ends of the upper horizontal axis into sectors upon which the shutter rests, and with which they are kept in contact by means of D straps. Fig. 9.

A great loss of water takes place in storage reservoirs owing to the flood water which has been backed up by the dam running off to the sill level of the byewash. At the Bhatghar Dam, in India, a series of gates slide in grooves in front of the byewash, and are almost balanced by counterpoises inclosed in chambers left in the masonry. When the water reaches its maximum level it flows by means of pipes into these chambers the outlets of which are smaller than the inlets. The weights of the counterpoises being thus much reduced, the gates fall and allow the excess of stored water to escape. When the level falls below the inlet pipes the water in the chambers escapes, so that the full weight of the counterpoises again coming into play, the gates are raised and the water impounded in the reservoir.

The author has designed a gate which effects the same purpose, but in a different manner, and which requires no chambers in the masonry. This gate is a compound one, consisting of a falling framework hinged to the floor of the byewash, and supporting a bascular gate between its vertical members. A simple tumbling plank hinged to the top of the main gate, when upright, keeps the bascular gate in position by means of a latching gear. The action of this regulating gate is as follows :—When the water rises to the fixed level it turns the top board over, and releases the catch, the bascular gate then swings open, thus taking most of the pressure off the framework, which is held in position by chains passing round wheels at the floor

level and attached to submerged tanks, which now rise and pull the gates down. As the water falls the tanks descend, thus allowing the gates to rise sufficiently to be forced upward by the outward rush of water.

When the irrigation farm is situated close to the river bank the water must be raised by pumping, and to effect this either steam, wind, or water power may be employed. Up to the present time, in this State, the steam engine is almost extensively used for this purpose.

The following is an example of an ordinary plant which irrigates 400 acres by means of a 15 inch centrifugal pump and an engine, lifting water about 25 feet. The crops irrigated are 300 acres of lucerne and 100 acres of cereals, watering taking place about 180 days in the year to a total depth of 24 inches. The expenses of the whole scheme are as follows:—

| | | |
|---|---|---|
| Cost of engine, boiler, pumps, etc. | £1,700 | interest £200 |
| ,, laying out the land ... | £300 | |
| ,, firewood 1 cord @ 5/- per day ... ... | | 45 |
| ,, engine driver @ 9/- ,, ... ... | | 81 |
| ,, oil @ 2/- per day ... ... ... ... | | 18 |
| ,, man irrigating @ 6/- per day... ... ... | | 54 |
| Total yearly cost ... ... ... ... | | £398 |

or say £1 per acre.

Sir S. McCaughey gives the total cost at 4/- to 4/6 per acre per watering, which with 5 waterings comes to about the same figure.

In America of recent years windmills have been largely used for irrigation, and owing to improvements in their construction and increase of sail area, they are proving very valuable machines for the purpose, and in that country a windmill is almost as common an object on a farm as a barn or the house the owner resides in. In this State

there is no reason why they should not be used to pump water from the rivers or from the sands and gravels of the Tertiary drifts. To make their employment a success, however, for irrigation purposes, it must be remembered that their power increases as the cube of the wind velocity, so that they should be strongly built and of large size. It is also essential that they should pump the water into large reservoirs, so that none of the power will be wasted, for it is an axiom in windmill irrigation that the time to pump is when the wind blows strongly. No expensive works are required to transform at least small portions of our arid plains into gardens, orchards, and meadow land, but only an increase in the number of existing wells, and the employment of more powerful windmills.

Hydraulic rams of a large size and modern make might also be used with great advantage for raising water, and they are the cheapest and simplest water lifters known. With an average fall of only 8 feet, 3,500 gallons of water can be raised 35 feet in 24 hours, so that with a battery of say 10 such rams, at a total cost of say £100, an area of 30 acres could be irrigated. These rams have been constructed of great power, and are installed in the French Department of Corrège, working under a head of 20 feet, raising 122 gallons per minute or 176,000 gallons per day to a height of 81 feet.

In this connection it may be of interest if I refer to a very ingenious contrivance, which has been lately used at Geneva for the purpose of increasing the available head of water required for working turbines or rams. Two jets of water are directed through the dam upon the surface of the lower stream, their action being to produce in it an artificial depression in which the outlet pipes are placed. Experiments have proved that by this means the head could be increased by as much as 30%.

Power might also be obtained by running water from the river, down deep wells to the tertiary drifts for the purpose of working turbines, whose power when transformed into electrical energy could be used for pumping river water for irrigation purposes. The horse power developed will $= \cdot 079\ Q\ h$, where Q is the quantity of water in cube feet per second, and $h$ is the fall in feet, so that if only one cubic foot per second is taken from the river and allowed to actuate a turbine at a depth of 120 feet, it will generate almost 10 HP. This power after making all due allowance for loss in conversion, will raise say 4 cubic feet per second or 1,500 gallons per minute to a height of 20 feet. The dynamo is to be worked direct by the turbine at the bottom of the well and the power conveyed by wires to the river bank.

When water has been stored it should be delivered to the consumers in measured quantities and with as little loss as possible. The measurement may be made in two ways, either by the use of meters or modules, the first of which indicates how much has been used, whilst the second only permits of a certain fixed quantity per minute to pass through it. Meters are well known under the following names :—Low pressure positive, in which all the pressure in the pipes is lost, and the quantity of water passing through them is actually measured. Inferential, in which the amount of water is inferred from the velocity of its flow, this velocity being measured by means of vanes. Venturi meters, in which the velocity of the water is shown by means of the height of water in a gauge. This is one of the best form of meters for measuring large quantities of water, as it has no working parts, and consequently no friction. The principle upon which it works, was discovered in 1797 by M. Venturi, who found that the flow of water in a pipe, past its junction with another pipe, created

a vacuum in the latter in which the water rose as the velocity increased.

For irrigation purposes it is however more convenient to have some means by which a fixed quantity of water can be delivered per minute, and to effect this object when the head varies, many forms of modules have been used but so far with but little success. The only one that at all meets these requirements at present was designed by Mr. A. D. Foot, C.E., whereby the head over the outlet orifice can be maintained with some degree of certainty by means of a long returning weir. A very simple and efficient form of module was designed in India many years ago by Lieut. Carroll, of which the following is a short description. Fig. 8. The mouth of the outlet pipe has a plate hanging in front of it, to which is attached a quadrant which more or less closes the waterway. At its highest position there is a free get-away for the water underneath it and between the lips of the outlet and hanging plate. If the velocity be increased, this plate is forced outwards and the quadrant descending into the tube decreases the flow.

The following is a description of a simple module which has been designed by the author (Fig. 7):—A gate free to slide up and down in front of the outlet is suspended from one end of a lever, the other end of which is attached to a tank floating in the main channel. To adjust this apparatus, close the gate down till the required discharge takes place under any given head. Then keeping the chains from the gate and tank stretched upwards, mark upon a board the position of the lever. Repeat this, with various heads, when a series of lines will be drawn on the board, marking the positions of the lever, draw a curve to which these lines form tangents, and cut the board along it. If now the lever rolls on this curve, the relation between the head of water and the size of the outlet must always be such that the discharge will be a constant quantity.

Water being stored and raised, it becomes necessary so to lay out and construct the distributing channels that the largest possible proportion of it shall be delivered on the land it is proposed to irrigate. The loss to the Victorian Irrigation Trusts from this cause is very great, amounting in many cases to between 40 and 50% of the total quantity raised. The experience of many of the Victorian irrigationists is that if their properties had been properly prepared and levelled, two or three times the area they now work could have been irrigated with the same amount of water. In fact the testimony of all the persons who irrigate land goes to prove that money is well expended upon the preliminary work in connection with designs and levels.

The gradients of the drains must be such that on the one hand no scouring out will take place, and on the other that no silting up of the channels will be caused. As to the cross sections, that of a semi-hexagon will give the maximum discharge, but the banks will have too steep a slope. A better form is to make the bottom and sides tangents to a semi-circle, when the top width will in all cases be equal to the sum of the slopes. The great loss due to evaporation may often be reduced by altering the sections of the drains, but in porous ground some protective measures must be taken.

At Mildura, lime concrete has been laid along the main channels and laterals, to the thickness of 3 inches in the former and 2 inches in the latter. The proportions used were 4 of broken stone, and 1 of slaked lime, and the cost was for the 3 inch 1/8 per square yard, and for the 2 inch 1/1½ per square yard. It has stood fairly well, but cracks do occur in it which permit of a certain amount of leakage. An improvement on this, though of course it would be more expensive, would be to have marsupial netting embedded in concrete 3 inches thick, such as I have used

as a protection to canal banks close to the scour caused by a regulating gate, where it showed no signs of leaking.

Tarred cloth has been used in America where it was found that with 12 oz. duck there was no seepage, even under conditions in which the banks would otherwise seep out as through a sieve. Good results may also be obtained by carting clay or silt into the head of the channel, and keeping it well stirred up till it forms a film over the bottom and sides.

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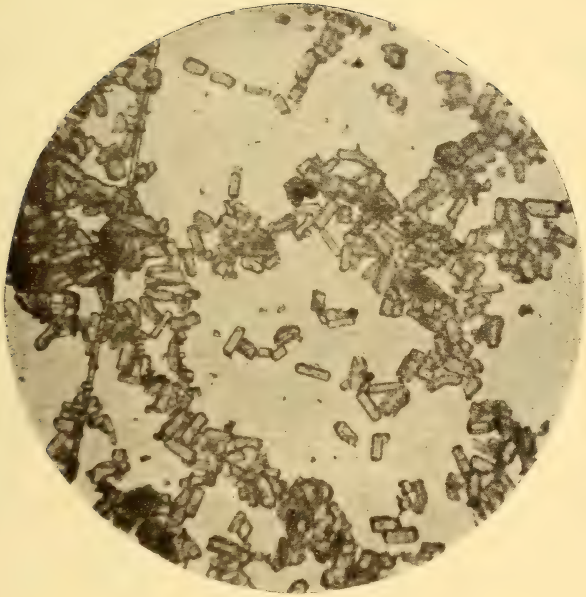

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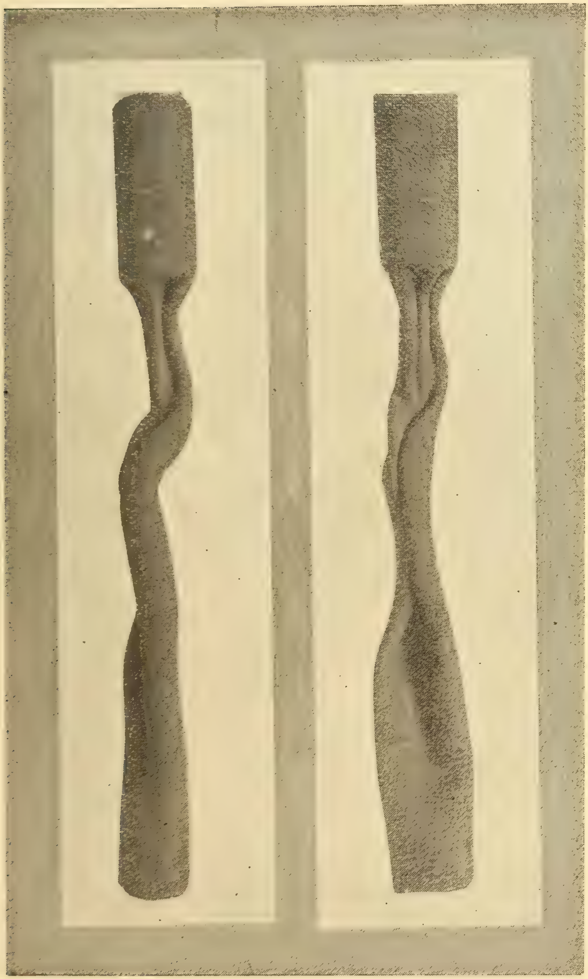

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